

**Examining the spatial and temporal patterns of crime in pre- and post-earthquake
Christchurch**

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Abstract

The 2010-2011 Canterbury Earthquakes brought devastation to the city of Christchurch and has irrevocably affected the lives of the city's residents. Years after the conclusion of these earthquakes, Christchurch and its residents are well on the path to recovery. Crime has proven an ongoing topic of discussion throughout this period, with news reports of increased burglary and arson in areas left largely abandoned by earthquake damage, and a rise in violent crime in suburban areas of Christchurch. Following the body of research that has considered the reaction of crime to natural disasters, this research has sought to comprehensively examine and understand the effects that the Canterbury Earthquakes had on crime.

Examining Christchurch-wide offending, crime rates fell over the study period (July 2008 to June 2013), with the exception of domestic violence. Aside from a momentary increase in burglary in the days immediately following the Christchurch Earthquake, crime rates (as of 2013) have remained largely below pre-earthquake levels. Using Dual Kernel Density Estimation Analysis, a distinct spatial change in pre-earthquake crime hotspots was observed. These changes included an enormous decrease in central city offences, a rise in burglary in the eastern suburbs, and an increase in assault in areas outside of the central city. Logistic regression analysis, using a time-compensated dependent variable, identified a number of statistically-significant relationships between per CAU crime rate change and factors measuring socio-demographic characteristics, community cohesion, and the severity of disaster effects.

The significance of these findings was discussed using elements of Social Disorganisation Theory, Routine Activity Theory, and Strain Theory. Consistent with past findings, social order was largely maintained following the Canterbury Earthquakes, with suggestion that increased collective efficacy and therapeutic communities had a negative influence on crime in the post-earthquake period. Areas of increased burglary and assault were associated with large population decreases, suggesting a link with the dissolution of communities and the removal of their inherent informal guardianship. Though observed, the increase in domestic violence was not associated with most neighbourhood-level variables. Trends in crime after the Canterbury Earthquakes were largely consistent with past research, and the media's portrayal.

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Chapter 1 Introduction

This research aims to understand how the Canterbury Earthquakes have affected the trends, distribution, and occurrence of crime in the city of Christchurch, New Zealand. Specifically to examine and understand how crime has varied temporally and spatially, and why these changes may have occurred. The Canterbury Earthquakes (2010-2011) greatly impacted both the people and the built environment of Canterbury, and in particular the city of Christchurch. As normality has begun to return to the region, Canterbury and Christchurch face a prolonged period of recovery that will result in great changes to the region's landscape and its people.

Past research has shown that natural disasters like the Canterbury Earthquakes can significantly impact the behaviour of those affected by the disaster. Among this research, criminal behaviour during and after disasters has been an area of focus, and one that has generated a great deal of contention, with many researchers finding contrasting results. In line with this past research, the following is an investigation of how crime in the city of Christchurch was affected by the Canterbury Earthquakes. This work represents the first such academic account of the Canterbury Earthquakes on criminal offending, and the first of any disaster-crime research in Australasia.

This introductory chapter describes the context of this research, specifically the events surrounding the Canterbury Earthquakes. This includes the geological significance of these earthquakes, and their effects on the physical and social fabric of Christchurch and the broader Canterbury. Attention is then drawn to the portrayal of crime by the media after the Canterbury Earthquakes, and specifically the links drawn between their effects and subsequent criminal behaviours. Finally, the objectives and structure of this research are outlined.

1.1 The Canterbury Earthquakes

Geological context

The Canterbury Earthquakes comprised a series of large seismic events that struck the Canterbury Region of New Zealand between 2010 and 2011. Of the thousands of recorded earthquakes, the two most significant events were, the first earthquake of the sequence, a

moment magnitude (M_w) 7.1 earthquake on 4 September 2010 (Darfield Earthquake), and a M_w 6.2 earthquake on 22 February 2011 (Christchurch Earthquake) (Bannister & Gledhill, 2012; Orense et al., 2011). In addition, thousands more aftershocks (of varying severity) have and continue to occur in the region, though in terms of economic and social consequences, and earthquake damage these two primary events were unparalleled.

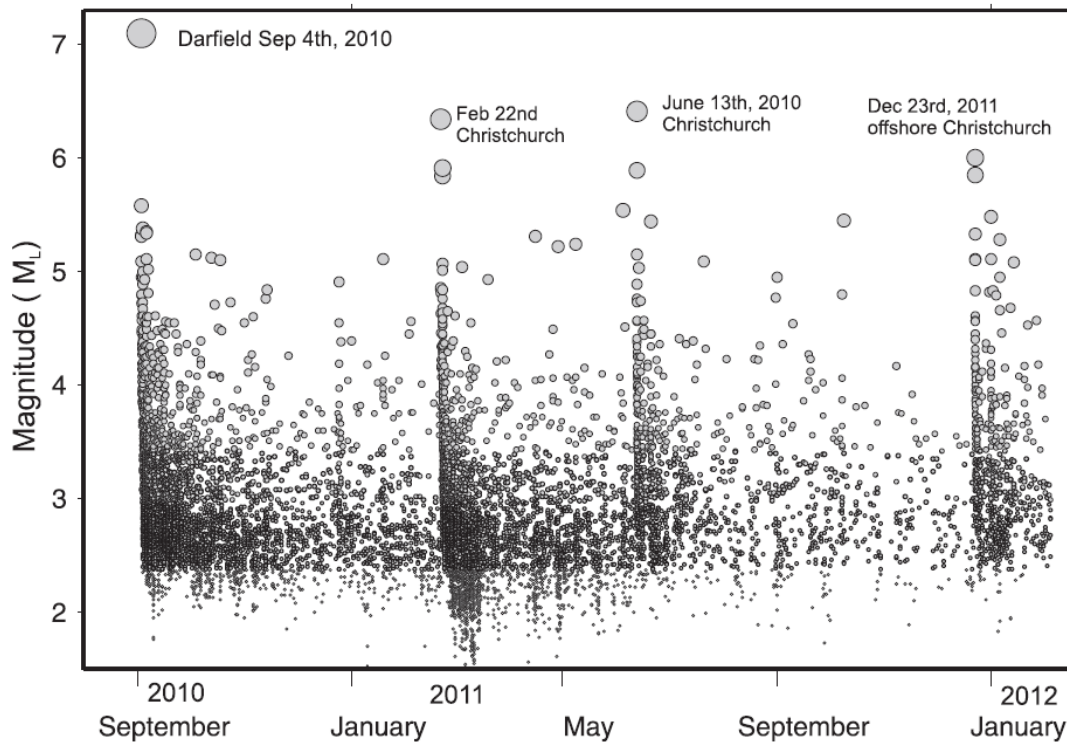


Figure 1 Temporal sequence of seismic events in the Canterbury Earthquakes (Bannister & Gledhill, 2012)

Figures 1 and 2 provide graphical summaries of the seismic events between September 2010 and the start of 2012. Figure 1 shows the temporal distribution of earthquakes, with four primary peaks followed by aftershocks decreasing in intensity and number. Figure 2 demonstrates the spatial distribution of earthquakes throughout five distinct periods of activity. The changing spatial distribution of aftershocks is apparent, shifting eastward after the initial seismic events, closer to the city of Christchurch. Figure 2c notably illustrates the occurrence of the Christchurch Earthquake, striking just outside of Christchurch, and east of most previous events.

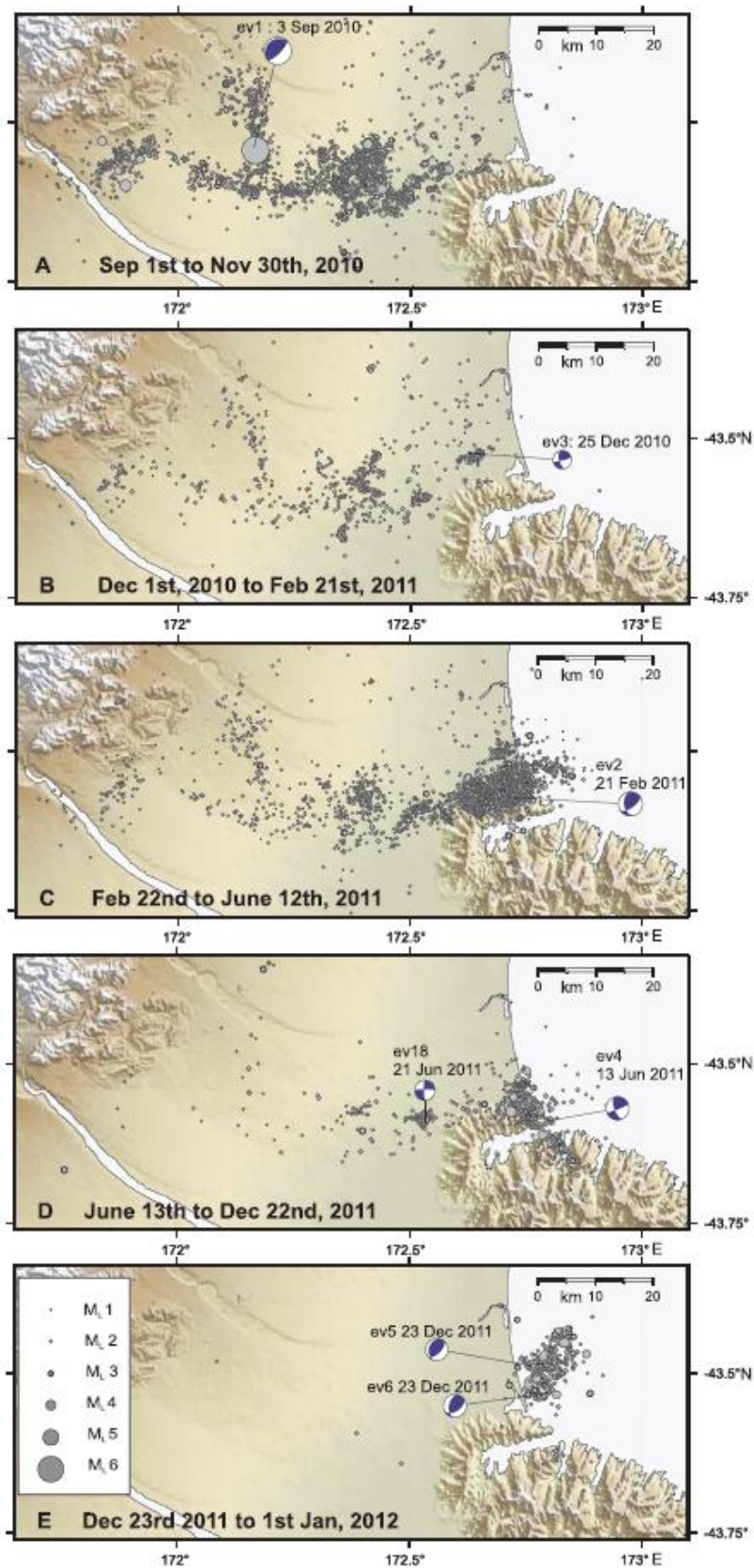


Figure 2 Time sequence and changing spatial distribution of seismic events of the Canterbury Earthquakes (Bannister & Gledhill, 2012)

The February 2011 event (Christchurch Earthquake) was notably smaller in magnitude than the September 2010 event (Darfield Earthquake), however it was responsible for a greater amount of damage and resulted in the death of 185 people. There were no fatalities from the earlier Darfield Earthquake. This disparity can be attributed to the higher peak ground acceleration observed during the Christchurch Earthquake (2.2g) compared to the Darfield Earthquake, which only measured 0.3g in Christchurch (Bannister & Gledhill, 2012). In addition to a number of geological factors that have been proposed as contributors to this increased ground acceleration, the mere proximity of the Christchurch Earthquake's epicentre to Christchurch's Central Business District (CBD), and the time of occurrence meant that its impacts were far greater (Kaiser et al. as cited in Bannister & Gledhill, 2012).

Liquefaction was an important impact of the Canterbury Earthquakes. Wallace (1995) describes liquefaction as the change of state of ground water, rock and soil materials into liquid by earthquake-induced shaking. Though liquefaction proved a major contributor to residential and infrastructure damage in Canterbury (Orense et al., 2011), its effects remained comparatively minor compared to previous examples, such as the 1964 Niigata Earthquake in Japan where liquefaction caused the collapse of entire buildings (Wallace, 1995). Liquefaction in both the Darfield and Christchurch Earthquakes was most concentrated in the river-adjacent eastern areas of Christchurch (Orense et al., 2011) .

Effects of the Canterbury Earthquakes

Whilst affecting the entire Canterbury region, the effects of the Canterbury Earthquakes were most concentrated in the city of Christchurch. These effects, both social and physical, are summarised below under the phases set out in the National Governor's Association (NGA) model of disaster response and recovery (National Governor's Association Center for Policy Research Washington D.C., 1979).

The NGA created a four phase model to conceptualise the states and actions of social and organisational responses to a disaster. Though replicated numerous times with minor alterations, the NGA's model includes four repeating phases: mitigation, preparedness, response, and recovery (see Figure 3). Commonly depicted as a cyclic model (see Figure 4), these four phases often reoccur with the repeated onset of disasters in the same area, such as repeated flooding, or earthquake aftershocks. The onset of the disaster serves as the only

clear division in the model, dividing the mitigation and preparedness phases, and the response and recovery. Aside from this, the content and duration of each phase has been acknowledged to overlap in both content and duration (Baird, 2010).

- Mitigation – “activities that actually eliminate or reduce the probability of occurrence of a disaster”.
- Preparedness – “necessary to the extent that mitigation measures have not, or cannot, prevent disasters . . . governments, organizations, and individuals develop plans to save lives and minimize disaster damage”.
- Response – “Response activities follow an emergency or disaster. . . . to provide emergency assistance for casualties . . . to reduce the probability of secondary damage . . . and to speed recovery operations”
- Recovery – “Recovery activities continue until all systems return to normal or better.”

Figure 3 Disaster response phases according to the NGA (National Governor’s Association Center for Policy Research Washington D.C., 1979, pp. 12-13)

This research focuses specifically on the two post-disaster phases (response and recovery) of the Canterbury Earthquakes. Occurring immediately after the onset of the disaster, the response phase consists of actions taken to mitigate and tend to the most critical disaster effects. Subsequent to this (though often indistinct in transition), the recovery phase begins and includes actions to further repair the effects of the disaster to levels close to, or exceeding pre-disaster levels (National Governor’s Association Center for Policy Research Washington D.C., 1979). In contrast to hurricane events that have featured prominently throughout disaster research (for example Cromwell, Dunham, Akers, & Lanza-Kaduce, 1995; LeBeau, 2002; Leitner, Barnett, Kent, & Barnett, 2011), the Canterbury Earthquakes differed in that the aftermath and recovery phase were not linear, and often renewed by significant aftershock activity, and of particular note, the Christchurch Earthquake, five months later.

The significance of these phases has been raised in past disaster-crime research (both explicitly and not) in relation to disparities between short, moderate, and long term trends in crime (see Leitner et al., 2011). As described later in the Methods section of this research, a

division is made approximating the boundary between the response and recovery phases. Analysis is completed on both the response and recovery periods, though is focused on the latter. To frame this research, the following is an account of the social and physical effects of the Canterbury Earthquakes, including both immediate (response), and longer-term (recovery) events.

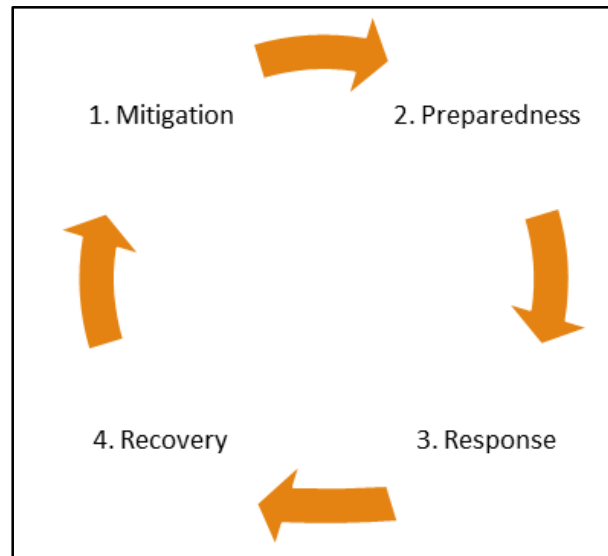


Figure 4 NGA’s model of the four stages of disaster response

Social effects

The Canterbury Earthquakes resulted in 185 fatalities (all during the Christchurch Earthquake) and thousands of injuries, mostly caused by falling debris, and actions during shaking (such as tripping whilst running) (Johnston et al., 2014). Aside from the disparity in the extremity of ground movement between the two earthquakes, Johnston et al. (2014) relate the disparity in deaths and injuries to the timing of each event. The Darfield Earthquake occurred in the early hours of a Saturday morning, minimising the population exposed to falling debris and building collapse (limited to the CBD), whilst the Christchurch Earthquake occurred near midday on a working day, maximising the exposed population.

In the immediate response to the Christchurch Earthquake urban search and rescue were deployed to locate and rescue those trapped in buildings and under rubble. In keeping with Auf Der Heide’s (2004) work, immediate aid and rescue work was performed by members of the public, police and fire services, before local, national, and international search and rescue groups took over. To aid in response efforts and in a law enforcement capacity, the New

Zealand Army was mobilised to Christchurch, paralleling the role of the National Guard in a number of disasters in the United States of America (US) (Bass, 2008; Cromwell et al., 1995; Lee, 2010; Leitner et al., 2011). In Christchurch, soldiers and Police from Australia helped to maintain and enforce the CBD Cordon to aid thinly-spread Police.

Though no single accurate record of population exists, population movement following the Christchurch Earthquakes (and to a lesser extent the Darfield Earthquake) was apparent in both the short- and moderate-term. Not uncommon following a natural disaster, such population movements have been a consideration in past disaster-crime research in both the disaster location, and where populations have relocated to (Bass, 2008; Leitner et al., 2011; Leitner & Helbich, 2011; Varano, Schafer, Cancino, Decker, & Greene, 2010). In the immediate aftermath of the two primary events of the Canterbury Earthquakes, an unknown number of residents are thought to have fled the city. Intra-city movement also took place as residents whose homes had been severely damaged were forced to stay with friends and family, or move to other temporary accommodation. Longer-term, the population exodus from Christchurch has continued, driven by dissatisfaction with post-earthquake living conditions, fear of further earthquake events, and the demolition of homes. Contrasting this outward population flow has been an in-migration of workers in construction-related roles, to satisfy the increase in demand generated by the 'Canterbury Rebuild' (Statistics New Zealand, 2011). These workers have been a highly visible group in post-earthquake Christchurch, and have been subject to a number of prejudices, including an association with criminal behaviour (see Dally, 2013b). An assessment of population changes is provided later in this work (see Methods).

A considerable amount of research has been completed on the ongoing mental and (to a lesser extent) physical health of residents after the Canterbury Earthquakes. An onset of increased stress, anxiety, and depression have been observed in residents following the Canterbury Earthquakes (Gawith, 2013; Osman, Hornblow, Macleod, & Coope, 2012; Renouf, 2012; Sullivan & Wong, 2011). Osman et al. (2012) found that increases in anxiety were more likely in females, the elderly, and individual who were married with children. Comparing two Christchurch suburbs, increased clinical depression and anxiety symptoms were observed in the suburbs suffering greater earthquake damage, whilst increased stress was seen across both suburbs (Renouf, 2012). Investigations of ongoing physical health after the Canterbury

Earthquakes have been limited, aside from Pearson, Kingham, Mitchell, and Apparicio's (2013) study investigating a relationship between the dust resultant from liquefaction and pneumococcal pneumonia. Aside from an increased risk of mental health disorders, the impact of the Canterbury Earthquakes has been relatively limited considering their intensity (McColl & Burkle, 2012). From this limited sample of health research, it is clear that the social implications of the Canterbury Earthquake are not just those that can be observed on a macro-scale, but equally those at an individual level, specifically in terms of mental wellbeing.

The effects of the Canterbury Earthquakes on communities have also drawn scholarly attention, specifically in how community cohesion was affected. The earthquakes were found to have increased community bonds, strengthening local communities, and promoting greater levels of care for neighbours and fellow community members (Gawith, 2013; Marlowe & Lou, 2013). This enhanced resilience and cohesion was observed in Christchurch's refugee communities, who in addition to being able to effectively aid their own members, noted a blurring of perceived social boundaries between those outside their own ethnic groups (Marlowe & Lou, 2013; Marlowe, 2013; Osman et al., 2012). A further example of this enhanced sense of community was the formation of the Student Volunteer Army, a sizeable group of university students who aided those worst affected by the Canterbury Earthquakes, most notably in the removal of liquefaction (Hayward, 2013; Lewis, 2013). Notably, studies identified that after the Canterbury Earthquakes, stronger communities were more able to promote better mental wellbeing and resilience (Osborne & Sibley, 2013; L. Thornley, Ball, Signal, Lawson-Te Aho, & Rawson, 2013).

Physical effects

The lateral and vertical movement of the Canterbury Earthquakes resulted in building damage throughout the region. The most serious of this damage occurred during the Christchurch Earthquake, though damage ranged considerably from the superficial cracking of paint, to extreme structural damage, and in rare cases, even the collapse of buildings. Earthquake damage resulting from the Canterbury Earthquakes was unevenly distributed throughout Christchurch, with the most severe damage occurring in the central city and in the areas now occupied by the Residential Red Zone. The Canterbury Earthquakes also proved damaging to the region's infrastructure, with liquefaction and lateral spreading disrupting telecommunications, power supply, water, and road networks.

Since the Christchurch Earthquake, the city has been in a constant and ever-changing state of recovery. Around 1600 buildings have required demolition, essentially leading to the destruction of Christchurch's CBD (Brownlee as cited in Parker & Steenkamp, 2012). In their place, new construction has been widespread throughout Christchurch. Though most disruption to Christchurch's infrastructure was resolved quickly (after both the Darfield and Christchurch events) and its impact short-lived, damage to water networks has continued to impact some areas, with ongoing repair work a crucial part of the recovery phase.

The *CBD Cordon* was established promptly after the Darfield Earthquake, and re-established following the Christchurch Earthquake, restricting public access to the central city with the intention of protecting the public from unstable buildings and to maintain security (Chang et al., 2014; McLean, Oughton, Ellis, Wakelin, & Rubin, 2012; Stevenson et al., 2011). Though short lived after the Darfield Earthquake, the CBD Cordon proved much more extensive and persistent following the Christchurch event, which remained in place for over two years. As a result of the CBD Cordon many businesses and offices were unable to open for extended periods, with many opting to relocate outside of the CBD.

The Residential Red Zone (see Figure 5) is a non-continuous area defined throughout residential areas in Christchurch, where earthquake damage was most severe, and where a substantial numbers of properties were deemed unsafe for habitation. The Residential Red Zone is present in three primary areas, including a cluster of suburbs to the north east of the CBD, the Port Hills (the most south eastern suburbs in Christchurch), and an area north of Christchurch. Damage to homes and poor earthquake-induced living conditions in the Residential Red Zone resulted in a substantial population exodus in these areas, which has left much of these areas uninhabited.

Both the social and physical effects of the Canterbury Earthquakes have been substantial and wide-ranging. Though not pervasive across Christchurch, these effects have been summarised in an effort to provide context of both the immediate- and longer-term reality of life in Christchurch. Later in this research some of these effects are included and considered for their ramifications on changes in post-earthquake criminal offending.

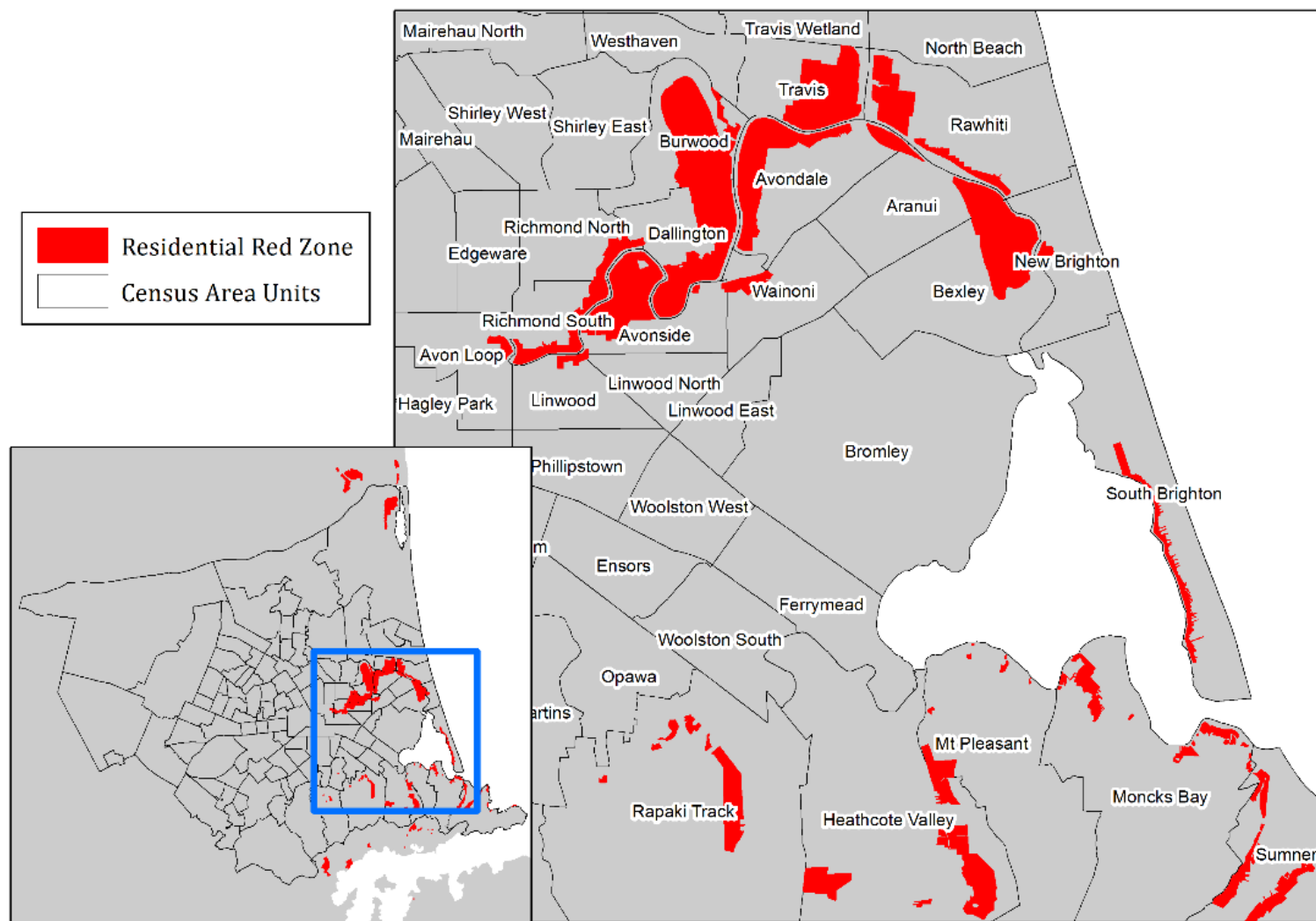


Figure 5 Map of the Residential Red Zone in Christchurch

1.2 Disasters and crime in the media

The media has proven to be a powerful influence on the public's perception of crime. Research internationally, and in New Zealand specifically has shown a link between media reporting of crime and the public's perception and fear of crime (Chiricos, Eschholz, & Gertz, 1997; Heath & Gilbert, 1996; Pawson & Banks, 1993; Smolej & Kivivuori, 2006). Moreover the media has been shown to have a substantial impact on public perception of how natural disasters affect crime, exemplified by the heavily contested 'looting myth' (Barsky, Trainor, & Torres, 2006; Gray & Wilson, 1984; Quarantelli, 1994). Media coverage of the two primary Canterbury Earthquake events was prolific both locally and internationally. Over time these media reports diverged to the way crime was affected by the earthquakes, combining anecdotal accounts with official statements from the New Zealand Police, at times blurring fact and fiction. A selection of reports from the New Zealand Herald, The Press, and Stuff.co.nz are covered here to ascertain how post-earthquake offending has been reported to the public.

Despite a reported decrease of property crime in 2011 (Mathewson, 2012), burglary, vandalism, arson, and other dishonesty offences have been a focus of post-earthquake media reports in Christchurch. The Residential Red Zone has been a frequent inclusion in reports of burglary, vandalism, and arson, with the substantial population exodus from these areas leaving remaining residents fearful for their property and safety amidst concerns of increased property crime (Gates, 2012; Heather & Lynch, 2012; Hume & Robinson, 2015). These anecdotal accounts cite the onset of population loss, the dissolution of local communities, and signs of property abandonment as the initial causes of increased burglary (Gates, 2012). In contrast, New Zealand Police officials report that crime in the Residential Red Zone has been effectively managed, and deterred with the aid of private security patrols hired by the Canterbury Earthquake Recovery Agency (CERA) (Gates, 2012; Hume & Robinson, 2015). The Riccarton area (to the west of the CBD) has also been highlighted as experiencing increased property crime (auto theft and shoplifting) by the media, as it has become an increasingly popular area for retail and hospitality activity following the Canterbury Earthquakes (Ensor, 2013). Though fraud and dishonesty offences were reportedly down 33.3 percent in 2011, media reports have highlighted a trend in fraud, burglary, and theft offending utilising the

pretence of damage or insurance inspections to enter homes (“Residents warned of hoax earthquake officials,” 2011; Stewart, 2012). Such reports are not without precedence, with past research focusing on the specific targeting of damaged homes for theft and fraud-related offences under the guise of repair or inspection work (Cromwell et al., 1995; Davila, Marquart, & Mullings, 2005).

An increase in arson offences has also been widely reported after the Canterbury Earthquake, with one such report even labelling Christchurch ‘Arson City’ amid reports of an apparent targeting of damaged and abandoned homes in the Residential Red Zone (Dally, 2013a; Heather & Lynch, 2012; Young, 2014). Reported statistics from the Christchurch Fire Service Investigation Unit, show a 50 percent rise in suspicious building fires between 2011 and 2012, with an increase offending on larger targets (such as buildings) (Dally, 2013a; Heather & Lynch, 2012). An increase in arson in the Residential Red Zone was seemingly supported by Anderson's report (2013) that the demolition of damaged homes in the Red Zone was being accelerated to and deter further arson and vandalism.

Media reports of violent crime following the Canterbury Earthquakes have centred on a change in the spatial distribution of assault hotspots and an associated rise of alcohol-influenced disorderly behaviour. Reported Police statistics show that the 2012/2013 financial year saw a 15.4 percent increase in assault offences in Canterbury on the year prior (Dally, 2013b). Anecdotal reports from local residents and business owners, and corroboration from Police officials shows that pre-earthquake hotspots of assault have moved away from past trouble areas in the CBD to other peripheral areas such as Riccarton (Ensor, 2013; Lynch, 2011b; Mathewson, 2012). These reports also note a rise in alcohol-influenced public disorder offences in and around Riccarton (Ensor, 2013, 2014; Lynch, 2011b). The earthquake-induced closure of bars and other entertainment in the CBD have been suggested as the reason for this displacement of crime, as residents turn their social and drinking activities to suburban venues and residential homes (Lynch, 2011b). Though public perception of these changes in violent and alcohol-influenced crime has largely been attributed to migrant earthquake workers, Police officials suggest that this is not the case, and offenders are in fact local residents (Dally, 2013b). A rise in sexually-motivated assault has also been observed, increasing on 2010 levels, and again on the 2011/2012 financial year (Dally, 2013b; Mathewson, 2012). Police statistics and recorded use of domestic violence services (such as

woman's shelters) showed a rise in domestic violence offences after the Darfield Earthquake, again after the Christchurch Earthquake, and similar increase after the substantial June 13 event in 2011 (Carville, 2011; "Crime spreads in Canterbury," 2011; Lynch, 2011a; Stylianou, 2011).

1.3 Conclusion

The Canterbury Earthquakes were comprised of two major events, the Darfield Earthquake (in September 2010) and the Christchurch Earthquake (in February 2011), in addition to thousands of more minor earthquakes. These earthquakes, and the Christchurch Earthquake in particular had considerable social and physical effects including the near destruction of the CBD and Residential Red Zone and (in some cases) critical damage to the city's infrastructure. Beyond these more visible effects, ongoing psychological disorders, the destruction of communities, and widespread population movement were also experienced as a result. In addition the media has reported that in the months following the Canterbury Earthquakes property crime (including burglary, vandalism, and arson) has increased in the Residential Red Zone, violent crime has shifted into more peripheral areas (and is often alcohol-related), and a region-wide increase in domestic violence. Christchurch is now in a perpetual state of rebuilding, changing not only its physical environment, but also the underlying social fabrics of the city and region.

1.4 Research objectives

This research aims to investigate how temporal and spatial patterns in crime have changed in Christchurch following the Canterbury Earthquakes, comparing these observations to those made in international research and in local media reports. These earthquakes represent an opportunity to expand past research that has examined the relationship between natural disasters and crime by exploring a new context, namely New Zealand and the Canterbury Earthquakes. Having already established the events and effects of the Canterbury Earthquakes, the following study looks to understand the repercussions of this disaster on criminal patterns. In addition, this research will also make comparisons to media reports of varying crime patterns following the Canterbury Earthquakes, determining if these reports have been an accurate representation of reality, or are simply the product of sensationalism. The following are the three main research objectives of this work:

- 1) To identify the short- and moderate-term temporal trends in crime in relation to the events of the Canterbury Earthquakes.
- 2) To map and identify areas that experienced the greatest spatial variation in criminal offending following the Canterbury Earthquakes.
- 3) To understand why some neighbourhoods experienced an increase or decrease in criminal activity using regression modelling.

1.5 Thesis structure

This *First Chapter* has outlined the context for this research, summarising the events that took place during the Canterbury Earthquakes, and their social and physical effects. A summary of crime, as reported by the media, is provided to gauge public perception on changes in offending.

Chapter Two provides a literature review of previous empirical research that has explored the relationship between disasters and crime, and highlights the mixed findings that exist on this topic.

Chapter Three provides a theoretical framework of prominent criminological and sociological theories that have been utilised in past disaster-crime research to explain criminal behaviour and patterns after a disaster.

Chapter Four outlines the methods undertaken to understand the temporal and spatial variations in offending after the Canterbury Earthquakes. The study area, data used, and analysis techniques employed are all detailed.

Chapter Five provides the results of the study and gives an account of the temporal and spatial variation in post-earthquake offending.

Chapter Six discusses the results, comparing them to past research, and the content of the theoretical frameworks introduced in Chapter Three, before an acknowledgement of the research limitations and suggestions for future research are given.

This work concludes with *Chapter Seven*, a summary of the key findings from this research.

Chapter 2 Literature Review

The following chapter provides an extensive review of past research into the effects of natural disasters on criminal offending. This body of research has grown significantly since the 1980s, with works frequently combining empirical and theoretical content to investigate disaster-related effects on both temporal and spatial patterns in crime. This research has included a diverse range of notable disasters, including earthquakes and floods, though none have been as frequently studied as the frequent hurricanes that have made landfall in the US. This review serves as the foundation for this work, providing commentary on what trends have been observed so far.

2.1 Crime after a natural disaster

The relationship between disasters and crime has proven to be a point of great contention throughout past research. Whilst popular opinion and media coverage would suggest that mass outbreaks of criminal activity are commonplace after a disaster, research findings have been more divided (Barsky et al., 2006; Gray & Wilson, 1984; Munasinghe, 2007). Findings have demonstrated support for an increase in crime (Gray & Wilson, 1984; LeBeau, 2002; Leitner & Helbich, 2011; Siman, 1977; Teh, 2008; Walker, Sim, & Keys-Mathews, 2012, 2014; Zhou, 1997), a decrease in crime (Barsky et al., 2006; Cromwell et al., 1995; Leitner et al., 2011; Watanabe & Tamura, 1995; Zahran, Shelley, Peek, & Brody, 2009), and the relative stability of crime (Miller, 2007; Munasinghe, 2007) during and in the aftermath of a disaster. Notably, no such research to date has examined the effects of the Canterbury Earthquakes on crime, nor for any disaster event in Australasia.

Property crime

Property crime has been the primary focus of the field of disaster-crime research, receiving the majority of academic attention in studies of post-disaster offending. Contrary to popular belief, observations of disaster-associated increases in property crime have been found in only a limited number of works, including Gray and Wilson (1984), LeBeau (2002), Siman (1977), and Zhou (1997). The most significant of these was Zhou (1997) who found that the annual rate of property crime in Tangshan, China, in the year of the 1976 Tangshan Earthquake, was more than double that of the year prior and subsequent. In Charlotte, North Carolina, LeBeau (2002) noted an increase in the number of police callouts relating to suspected burglaries after Hurricane Hugo in 1989, whilst a rise in reported property crime was also found to be associated with the 1972 flooding in Wilkes-Barre, Pennsylvania, resulting from Hurricane Agnes (see Gray & Wilson, 1984; Siman, 1977).

More recent research, at sub-city spatial resolutions, has observed localised increases in property crime following disasters. Research into the effects of Hurricane Rita in Houston, Texas in 2005 found that in the week of Rita's landfall, burglary offences tripled (Hagenauer, Helbich, & Leitner, 2011; Leitner & Helbich, 2011). Combining Scan Statistics and Dual Kernel Density Estimation techniques, Leitner and Helbich (2011) identified a large clustering of burglary offences, and a number of smaller clusters of theft from motor vehicles during Hurricane Rita's landfall. The occurrence of these clusters, which were statistically-significant in both space and time, illustrated that although a city-wide increase in burglary occurred, this increase varied in intensity across Houston. Interestingly, similar clusters of auto theft, coincident with Hurricane Rita were found as far as Miami, Florida (see Walker et al., 2014). Again using Scan Statistics and Kernel Density Estimation, similar clusters of property crime were also found during Hurricane Wilma (2005), in Miami (for burglary and larceny-theft), and Hurricane Ivan (2004) in Mobile, Alabama (for burglary, larceny-theft, and auto theft) (Walker et al., 2012, 2014).

Analysing these hurricane-associated hotspots of property crime, Leitner and Helbich (2011) and Walker et al. (2012, 2014) found that their locations differed from the areas where burglary usually tended to cluster. These observations suggest that disasters may influence and affect the 'usual' spatial distribution of crime in cities, away from traditional hot and

coldspots. Using regression analysis, Leitner and Helbich (2011), and Walker et al. (2012, 2014) identified associations between these areas of increased offending and various neighbourhood level factors including socioeconomic status, ethnic heterogeneity, home ownership, vacant homes, population density, and education. This specific area of research has provided suggestion that city-wide crime figures provide only a generalised picture of post-disaster criminal patterns, and that sub-city spatial resolutions need to be considered to examine localised changes in offending.

Conversely, numerous studies have observed decreases in property crime following a natural disaster. Media coverage of Hurricane Katrina fixated on the seemingly widespread proliferation of crime, an assertion supported by Frailing and Harper's (2010) reporting of a 403 percent increase in burglary rate in New Orleans. However other authors have provided evidence to the contrary, with explicit observations of decreased crime after Hurricane Katrina (see Barsky et al., 2006; Leitner et al., 2011; Leitner & Guo, 2013). Barsky et al. (2006) and Leitner et al. (2011) both observed a notable decrease in property crimes in relation to Hurricane Katrina. Barsky et al. (2006) identified that the annual total of burglary and theft offences in New Orleans was lower than the previous year. Using Autoregressive Integrated Moving Average modelling, Leitner et al. (2011) observed statistically-significant decreases in property crime across eleven of Louisiana's counties following Hurricane Katrina (with none increasing). Building on these findings, Leitner and Guo (2013) observed that in the month following Hurricane Katrina, the composition of property crime favoured burglary offences over larceny and robbery. Overall these findings contested the media's account of widespread crime in New Orleans and Louisiana after Hurricane Katrina, with suggestion that property crime actually fell.

Aside from Hurricane Katrina, similar evidence of falling property crime after a natural disaster has been found in a number of different events. For example, Cromwell et al. (1995) noted a decrease in property crime in Miami Dade County after Hurricane Andrew in 1992, whilst Watanabe and Tamura (1995) reported a drop in official crime statistics following the Great Hanshin Earthquake in Japan despite 40 percent of surveyed residents perceiving crime to have increased. Testing the effects of disaster frequency on crime in Florida between 1991 and 2002, Zahran et al. (2009) found an association between higher frequencies of natural disaster and lower levels of property crime.

A third further outcome, though rarely considered, is that during and after a disaster, crime remains essentially unaffected. For example, Lee (2010), and Siegel, Bourque, and Shoaf (1999) found a stability in property crime levels after the Northridge Earthquake in Los Angeles, California in 1994. Lee (2010) suggests that the Northridge Earthquake had no appreciable effect on crime and any slight variation reflected national-level influences and patterns in crime. Finally, Munasinghe (2007) noted an absence of property crime in Sri Lanka following the 2004 Boxing Day Tsunami, suggesting that crime remained relatively stable. Considering this wealth of research of trends in property crime, evidence has supported all possible outcomes, though those observing decreases in property crime have proven most numerous.

Looting

Looting, as a property crime, has been one area of particular focus of past disaster-crime research. Though the term looting conjures images of retail stores being pillaged in the absence of law and social order, past disaster research has considered a broader definition including theft and burglary from places of residence. Gray and Wilson (1984, p. 2) define looting as an offence conditional on the context of a disaster, as ‘both grand and petty larceny of personal property during and after disaster impact’. Moreover, Barsky et al. (2006) distinguish looting, the taking of non-essential items, from appropriation, which defines the taking of items motivated by survival.

Disaster-induced vulnerability has been a concept central to looting research, with a number of researchers drawing an association between home damage (from the disaster) and the likelihood of burglary victimisation (Gray & Wilson, 1984; Watanabe & Tamura, 1995). Gray and Wilson (1984) term looting as a result of increased vulnerability from disaster damage as *situational contingency*. Such a relationship usually has an inherent spatial variability, as areas less afflicted by disaster effects have been associated with more modest changes in crime rates. This is illustrated by Zhou (1997), who observed that increases in crime rates, whilst extreme near the epicentre of the Tangshan earthquake, were more measured with increasing distance from Tangshan.

Though historically media and other anecdotal reports have typically indicated a prevalence of mass looting following a disaster, Zhou (1997) has provided the only clear evidence of such an effect, citing that mass looting (followed by individual theft) was the most prominent

offence among elevated property crime rates after the 1976 Tangshan Earthquake. In fact, other research has suggested that mass looting is far more rare, and even a fictitious construction born from exaggeration and sensationalism by the media, an idea that has been deemed the 'looting myth' (Auf Der Heide, 2004; Barsky et al., 2006; Gray & Wilson, 1984; Leitner et al., 2011; Quarantelli, 1994). Gray and Wilson (1984), and Siman (1977) both suggest that looting was limited (with victimisation in less than 10 percent of their samples) following both the 1972 Flood in Wilkes-Barre, Pennsylvania, and the 1974 Tornado in Xenia, Ohio. Furthermore, after the 2004 Boxing Day Tsunami, Munasinghe (2007) highlighted a distinct lack of looting in Sri Lanka. In the aftermath of Hurricane Andrew in South Dade County, looting was limited, with Cromwell et al. (1995) attributing initial offending to local opportunistic youths, and later offences to out-of-town workers thieving from the properties they were employed to repair. Law enforcement officials in New Orleans commented that despite perceptions of widespread looting during Hurricane Katrina, actual cases of looting were extremely limited, and only became of concern once residents returned to New Orleans (Barsky et al., 2006).

Contrary to media accounts, the advent of widespread and pervasive looting after a natural disaster has found little academic support. Instead researchers suggest that whilst looting has been observed previously, it is far more limited than the media has portrayed.

Violent crime

Compared to the breadth of disaster-crime research that has examined trends in property crime, research investigating the impact of disasters on violent crime has been far less forthcoming, except for a few notable studies (see Leitner et al., 2011; Zahran et al., 2009; Zhou, 1997). Similar to their findings of increased property crime in Tangshan and Tianjin (China) after the Tangshan Earthquake, Zhou (1997) also observed a rise in violent crime rates. Of the few other examinations of violent crime after a disaster, all have noted a relative decrease in violent offences or the absence of any effect (Cromwell et al., 1995; Lee, 2010; Leitner & Helbich, 2011; Watanabe & Tamura, 1995). Specific evidence of falling violent crime was identified in the aftermath of Hurricane Katrina (see Leitner et al., 2011), whilst Zahran et al. (2009) found a negative relationship between disaster frequency and violent crime in

Florida, suggesting that the general societal reaction to experiencing disasters is a reduction in violent crime.

In general, disaster-crime research has largely neglected the effects of disasters on conventional violent crime, though domestic violence has proven to be a significant area of interest. Zahran et al. (2009) for example, found a positive relationship between domestic violence and the frequency of hurricanes affecting areas of Florida between 1992 and 2005; a finding shared with a number of other works (Adams & Adams, 1984; Enarson, 1999; Fothergill, 1996; LeBeau, 2002; Morrow, 1997). In the aftermath of the Mount Saint Helens ash fall event, Adams and Adams (1984) identified a 45.6 percent increase in domestic violence offences in Othello, Washington, whilst LeBeau (2002) highlighted a rise in police callouts for domestic disputes after Hurricane Hugo in Charlotte, North Carolina in 1989. Less direct research, such as the interviewing of residents, government and city officials, and providers of battered women's support and women's shelter services, has been forthcoming with similar findings. This research has found suggestion of increases in domestic violence in Dade County, Florida after Hurricane Andrew (Morrow & Enarson, 1996; Morrow, 1997; Wilson, Phillips, & Neal, 1998), in the Loma Prieta Earthquake in California (Wilson et al., 1998), and following a number of flooding events throughout the US and Canada (Enarson, 1999).

Impact of population movement

Throughout the discussions of disaster-crime research, many disaster effects have been proposed as explanations or influences on observed trends in offending. Collective efficacy, changes in formal and informal guardianship, and psychological stresses, have all been frequent considerations by researchers examining the impact of disasters on crime, though none have seen the same degree of explicit testing as population movement. Post-disaster population changes have been a prominent consideration by a number of researchers, including Bass (2008), Leitner et al. (2011), Leitner and Helbich (2011), and Varano et al. (2010).

Hurricane Katrina resulted in widespread evacuations along the Gulf Coast, displacing vast numbers of evacuees into nearby cities and states. Leitner et al. (2011) suggest that intra-

state population movement in Louisiana after Hurricane Katrina was responsible for a dispersion of prior criminal hotspots, forcing resident offenders into different areas.

Inter-state population movement was examined by Bass (2008) and Varano et al. (2010), following media reports linking evacuees to surges in crime in their host cities. Both studies analysed how evacuee arrival influenced longitudinal trends in crime in evacuee-receiving cities. Bass (2008) noted that evacuee arrival had no statistically-significant impact on violent or property crime rates, when comparing ten such cities against ten control cities that did not receive evacuees over a 23 year period. Varano's (et al., 2010) work similarly analysed the impact of evacuee arrival in Houston, San Antonio, and Phoenix on crime rates, and identified statistically-significant relationships with elevations in murder and robbery in Houston, and murder in Phoenix.

Comparing these two studies, Varano et al. (2010) disputes Bass's (2008) non-significant findings, arguing that evacuee arrival in Houston did have a limited impact on crime rates. Each study differed considerably in method, including the temporal resolution (annual in Bass (2008) and week in Varano et al. (2010)), which may explain the discrepancies in findings. Neither study delineated whether offenders or victims were evacuees or prior residents, limiting their observations to macro-scale trends, potentially concealing micro-scale patterns in offending or victimisation (as suggested by Leitner et al. (2011)).

Further to the discussion of the effects of population movement, Cromwell et al. (1995) in investigating the effects of Hurricane Andrew in South Dade County, and Davila et al. (2005) in examining Tropical Storm Allison and the 2002 San Antonio Floods, both comment on an increase in offending following post-disaster population movement into affected areas. Cromwell et al. (1995) and Davila et al. (2005) both noted an increase in repair- and construction-related fraud following Hurricane Andrew and Tropical Storm Allison (respectively), following the arrival of labourers to disaster-affected areas. In addition, Cromwell et al. (1995) remarked on a number of anecdotal reports that also linked these out-of-town tradespeople and construction workers to alcohol-influenced violence and public disorder, and illegal drug use. Given these observations, disasters may also serve as a mechanism by which the criminally-inclined may be drawn to affected areas to victimise and exploit populations made vulnerable by the disaster.

2.2 Conclusion

Research of criminal offending after a natural disaster has become increasingly common. Though this research has found evidence of both increased and decreased levels of crime after disasters, in general, the latter has been more prevalent. Against popular societal beliefs, it would appear that, at least in most cases, disasters have a negative effect on crime levels. In-line with the imagery often associated with disasters, property crime has been central to these studies, whilst violent crime has remained comparatively unexplored. Domestic violence has been an exception however, with a number of academics finding evidence of disaster-associated increases in domestic assaults (see Adams & Adams, 1984; Enarson, 1999; Fothergill, 1996; LeBeau, 2002; Morrow, 1997; Zahran et al., 2009). Localised variations in offending, such as the neighbourhood-level spikes in property crime observed by Leitner and Helbich (2011) and Walker et al. (2012, 2014), have demonstrated a spatial complexity to disaster-crime effects occurring at finer levels of spatial resolution.

Most of this previous disaster-crime research has primarily focused on the effects of hurricane and flood events in the US, with other types of disaster events in other parts of the world largely neglected. As such, this research serves as the first academic account of the effects of the Canterbury Earthquakes on crime in Christchurch, New Zealand.

Chapter 3 Theoretical Framework

The following chapter provides a theoretical framework for this research that will be used to guide the empirical analysis and aid in the understanding of the results. This framework is constructed around three key criminological theories including Clifford Shaw and Henry McKay's (1942) *Social Disorganisation Theory*, Lawrence Cohen and Marcus Felson's (1979) *Routine Activity Theory*, and Robert Agnew's (1991) adaptation of *Strain Theory*. All three theories have been used frequently by researchers throughout criminology to explain criminal behaviour and patterns. These theories, and in particular Social Disorganisation and Routine Activity Theory, have been key throughout research and discussions of disaster-associated changes in crime. Based on this theoretical framework, three hypotheses are made for the expected reaction by criminal elements to a disaster like the Canterbury Earthquakes, so that these ideas may be tested in this research.

3.1 Social Disorganisation Theory

Shaw and McKay's (1942) Social Disorganisation Theory was formed around the notion that social control, or lack thereof, influences the propensity of crime. Observing a persistence of delinquency in certain neighbourhoods over long periods of time, Shaw and McKay (1942) argued that specific structural elements within a community or neighbourhood influenced *social disorganisation*, and as a result, the development of crime. These elements may in turn be mitigated by other facets of community structure that aid *social organisation* and an ability to control the development of delinquency and crime. In considering this influence, Shaw and McKay (1942) argue that stronger communities are more effectively able to limit and regulate delinquent behaviour, and that the inclusiveness or exclusiveness of this community influences how effective a community may be in this respect. Social Disorganisation Theory proposes that crime patterns may be predicted by the observation of neighbourhood-level factors representing conditions hindering community development, and favouring social disorganisation. Shaw and McKay's (1942) original theory focused on three macro-level structural representations of communities that represented barriers to community cohesion, the prevention of social bonding, and the ability to share and realise common values;

- 1) low socioeconomic status,

- 2) high residential mobility, and
- 3) high ethnic heterogeneity

Sampson and Groves (1989) summarised the significance and influence of these factors. *Low socioeconomic status* was theorised to reduce the ability of persons to attend and partake in community activities used to strengthen community ties. *Residential mobility* represents the ability of residents to form community attachment and involvement, with high proportions of rental properties promoting shorter periods of residence and a reduced ability to become accepted by a community. Lastly, *ethnic heterogeneity* measures the relative proportions of ethnic groups in an area, with more heterogeneous areas promoting the segmentation and separation of groups, reducing community cohesion by limiting the ability to communicate, share and achieve common values and goals.

One of a number of works extending Shaw and McKay's (1942) initial theoretical framework, Sampson and Groves (1989) expanded and tested Social Disorganisation Theory to measure and model the influence of communities on delinquency and crime. They include five further factors;

- 4) supervision of peer groups,
- 5) friendship networks,
- 6) organisation participation,
- 7) single parent households, and divorced or separated couples, and
- 8) urban areas

Acknowledging the difficulty of measuring and even defining a 'community' or 'neighbourhood', Sampson and Groves (1989) apply qualitative measures to measure the extent of social and community networks that further approximate the potential effectiveness of community prevention of delinquency. Participation in local groups and organisations measures the attachment and involvement in more explicit representations of community, such as sports clubs and community boards. Applying Sampson's (1987) prior work, Sampson and Groves (1989) add measures of family stability (divorce and separation rates) to test more immediate intra-family control over youth behaviour. Finally urban areas were considered less able to apply the concepts of community influences and prevention of delinquency compared to suburban or rural contexts (Sampson & Groves, 1989).

Social Disorganisation Theory and disasters

The influence of communities in effecting informal social control forms the cornerstone of Social Disorganisation Theory. These ideas have been frequently applied in disaster-crime literature to explain observed changes in crime. Natural disasters represent a sudden disruption, and in some cases a complete loss, of social order in which antisocial behaviours can emerge (Gray & Wilson, 1984; Quarantelli, 1994; Teh, 2008). Despite this, the influence of communities, based on Social Disorganisation Theory, has been used to explain why outbreaks of mass crime have rarely been observed in the aftermath of a disaster (Quarantelli, 1994).

A general absence of mass crime breaks after disasters has frequently been attributed to the influence of communities. Authors propose that instead of creating anarchy, disasters may instead act as a catalyst to enhance prior community cohesion, enhancing the community's ability to effect social control (Auf Der Heide, 2004; Leitner et al., 2011; Miller, 2007; Munasinghe, 2007; Quarantelli, 1994; Zahran et al., 2009). Miller (2007) (among others), relates this to Barton (1969) and Fritz's (1961) (as referenced by Miller, 2007) concept of therapeutic communities. The author suggests that therapeutic communities develop due to increased empathy and shared hardship following a disaster, which promotes pro-social and altruistic behaviours, and increases collective efficacy. As a result, community cohesion is increased, and in keeping with the ideas of Social Disorganisation Theory, crime is thought to decrease. Evidence would suggest that such effects are only temporary (Leitner et al., 2011).

Despite numerous researchers observing a general decrease in offending after a natural disaster, increased domestic violence rates have been frequently observed (both in isolation and as behaving distinctly from other types of crime) (Adams & Adams, 1984; Enarson, 1999; Fothergill, 1996; LeBeau, 2002; Morrow, 1997; Zahran et al., 2009). Observing this distinction between regular crime and crime in domestic-contexts, Zahran et al. (2009) argued that domestic violence is somewhat immune to a community's ability to reduce crime and effect informal social control, resulting in its increase in the presence of other contributing factors after a disaster.

Other researchers have argued in opposition of such increases in collective efficacy, suggesting that disasters may instead disrupt communities, increasing social disorganisation

and reducing these crime-mitigating effects (Davila et al., 2005; Siegel et al., 1999; Varano et al., 2010). In opposition to more popular arguments, Davila et al. (2005) propose that the trauma caused by disasters may instead weaken the resolve of those affected, decreasing their sense of community attachment and leaving them more vulnerable to victimisation (Erikson as cited in Davila et al., 2005). Considering the physical effects of a disaster, others have reasoned that the population movement that often results from disasters may breakdown communities through the removal of local residents (see Varano et al., 2010). In an investigation of mass population change after Hurricane Katrina, the researchers theorise that the isolation of residents from usual social and community networks, and their arrival in foreign locations, increased social disorganisation, making them potentially more vulnerable to offending and/or victimisation.

3.2 Routine Activity Theory

Routine Activity Theory was developed by Lawrence Cohen and Marcus Felson in the 1970s to explain the occurrence of crime as the result of a population's *routine activities* controlling the convergence of the three essential components of all *direct-contact predatory violations* (Cohen & Felson, 1979).

These three components are:

- a motivated offender,
- a suitable target, and
- the absence of a capable guardian

Cohen and Felson's (1979) work focuses on the explanation of rising property crime rates in the US, despite overall trends suggesting that crime should fall. They proposed that the changing routine activities of the American population had resulted in the increased convergence of motivated offenders, suitable targets, and lack of capable guardians, influencing the observed rising crime rates. One's routine activities revolve around multiple locations; place of residence, place of employment or education, and place(s) of social activities, and it is along these routine activities that the convergence of offenders, targets, and guardians occurs (Cohen & Felson, 1979; LeBeau, 2002). Through changes to the locations involved in a population's routine activities, such as the influence of a natural disaster, it is conceivable that the locations of convergence, and hence where crime occurs may change.

Cohen and Felson's (1979) original theory revolves around three essential components that must converge in a given moment and place for a crime to occur. For any direct-contact predatory violation to occur, a motivated offender must meet a target, deemed to be suitable to them (the offender) in both space and time, whilst in the absence of capable guardianship

1. **Offenders** must be motivated and have the means to commit a crime. This motivation may change and be affected by local conditions and the situation of the offender. Proximity to potential targets is critical to the idea of convergence, as has been shown that offending occurs near to the offender's routine activities, and in proximity to their homes (A. M. Thornley, 2004).

2. **Targets** must be suitable, meeting the needs and requirements of the offender, which may relate to perceived value, offending preferences, and the vulnerability of the target. The location of targets, relative to offenders and their routine activities, is critical as to whether a potential target becomes victimised.
3. **Guardianship** must be absent to a level deemed acceptable by an offender, where the risk of being caught is sufficiently low compared to the perceived benefits of committing the crime. Guardianship may be formal such as the presence of a law enforcement officer, informal such as a community watch group or a neighbour, or technological in the form of a burglar alarm.

Routine Activity Theory has been frequently utilised throughout environmental criminology. The applications of Routine Activity Theory have focused on two main areas: the first considers how individual or mass changes in the location and/or timing of routine activities affect the likelihood of crime occurring and where this may take place. Second, the treatment of the three components of Routine Activity Theory as an equilibrium system, affected by changes to the quantities of each component, upsetting the relative balance of crime levels as the likelihood of convergence increases or decreases in response.

Routine Activity Theory and disasters

Routine Activity Theory has proven to be another key theory in the discussion and explanation of changes in criminal offending following a natural disaster. Applications of Routine Activity Theory to post-disaster offending have generally originated from three sources: changes in the presence of capable guardianship, changes in the number of offenders, and changes to a population's routine activities.

Of the many applications of Routine Activity Theory to post-disaster crime research, discussions around the presence and effectiveness of guardianship have featured the most prominently. Firstly, disasters have been seen as a mechanism for the reduction, and even the complete removal, of formal guardianship (police personnel). After a disaster, the presence and ability of law enforcement to effect control may diminish through their preoccupation with relief and aid activities, or through a loss of telecommunications, or physical impediments (such as damaged roads) after a disaster (Cromwell et al., 1995; LeBeau, 2002). This removal of guardianship presents offenders with criminal opportunities where the

likelihood of being witnessed committing these criminal acts is reduced, leading to an increase in offences.

Conversely, disasters have also been considered as being responsible for increases in formal guardianship. After Hurricanes Katrina (in New Orleans) and Andrew (in South Dade County, Florida), and the Northridge Earthquake (in Los Angeles), the arrival of the National Guard has been credited as having maintained (and even increased) order, preventing an expected increase in offending (Cromwell et al., 1995; Lee, 2010; Leitner et al., 2011).

Further discussion has surrounded an increase in levels of informal guardianship, tied heavily to discussions (summarised earlier around Social Disorganisation Theory) around increased community cohesion after a disaster. Extending these ideas to Routine Activity Theory, Cromwell et al. (1995) and Zahran et al. (2009) suggested that as a result of increased neighbourly concern and community reliance, informal guardianship becomes more prevalent following a disaster, which may provide increased deterrence to offending, even in the absence of formal guardianship. Cromwell et al. (1995) observed a rather extreme example of the significance of informal guardianship after Hurricane Andrew, where neighbourhood groups (in some cases armed) were able to control crime in the absence of law enforcement. The inverse argument has also been made however, with Leitner and Helbich (2011) suggesting that the evacuations that preceded Hurricane Rita were in-part responsible for increases in burglary, as homes were left unattended by informal guardians. Similarly, Zhou (1997) proposed that the extreme death toll of the Tangshan Earthquake removed the presence of effective guardians in homes, which led to increased burglary and theft.

A second application of Routine Activity Theory has noted the influence of disasters in increasing the abundance of motivated offenders. Barsky et al. (2006) alluded to the idea that persons may be driven to commit offences, such as the theft of food and water, in the event that disasters create a shortage of essential supplies. Furthermore, Cromwell et al. (1995) and Davila et al. (2005) both observed an increase in offending due to the arrival of the criminally-inclined to prey on those suffering disaster-related home damages.

A third application of Routine Activity Theory in disaster-crime research has been through the modification of a person's routine activities following the disaster. LeBeau (2002) reasoned

that the temporary absence of employment and education commitments, increased the time spent performing the more crime-prone discretionary activities. The author reasons that this change presents offenders with increased criminal opportunities that result in greater levels of offending. Cromwell et al. (1995) alluded to a similar idea in the immediate aftermath of Hurricane Andrew, where most initial opportunistic offending was attributed to local youths, who without school or participation in relief work, their criminal opportunities were thought to increase. This change has also been proposed as an explanation of increased domestic violence, in that offenders and victims spend greater amounts of time in cohabitation, but also that this cohabitation increases the number of potential witnesses to offending, leading to higher numbers of reports (see LeBeau, 2002; Zahran et al., 2009).

3.3 Strain Theory

Social Disorganisation and Routine Activity Theory have so far provided the theoretical foundations for the overwhelming majority of disaster-crime research. Whilst Strain Theory has been a common inclusion in other criminology research, it has largely been absent from disaster-crime research (with the exception of Robertson, Stein, & Schaefer-Rohleder, 2010). Curiously, themes and ideas similar to those in Strain Theory have been used in disaster-crime research, though without an explicit link between the two.

In applying general Strain Theory to explain a possible source of criminal offences, Agnew (1992) states that intra- and inter-personal interactions can lead to strain that in turn develops criminal motivations in a person that lead to offending as an outlet for this strain. Agnew (1992, 2001) remarks that external physical events may act as additional stressors, further impacting the strain experienced by individuals. A link can be made to the onset of a disaster and its subsequent effects acting as an external stressor, soliciting an emotional and psychological response that may create increased strain within an individual that may lead to increased criminal behaviour (Agnew, 2001).

Strain Theory and disasters

Though Strain Theory may be applied to all forms of crime, its use to explain offending post-disaster is most applicable to changes in domestic violence (Adams & Adams, 1984; LeBeau, 2002). Though not explicitly cited by researchers of crime after a disaster, parallels with Strain Theory are clear, with losses, both direct (loss of loved ones and homes) and indirect (financial repercussions) being attributed to increases in domestic violence (Adams & Adams, 1984; LeBeau, 2002). Furthermore, Varano et al. (2010) note that population movement as a result of a natural disaster may remove affected individuals away from institutional, social, and/or familial support, which may in turn leave increased personal strain unmitigated. In this light, Strain Theory may be applied as one possible explanation of increased domestic violence after a disaster, as the disaster's effects contribute to personal strain, which may in turn manifest as violent offending against domestic partners and other family members (Agnew, 1992).

3.4 Conclusion and expectations

Social Disorganisation Theory focuses on the influence of communities in informally controlling their own criminal element. Following a disaster this influence is thought to fluctuate, acting as a mechanism controlling observed changes in offending.

Routine Activity Theory defines criminal activity as the product of a population's routine activities that control the convergence of offenders, targets, and guardianship. Applications of this theory after a disaster have been numerous, focusing on post-disaster changes to person's routine activities, and changes to the relative abundance of offenders, suitable targets, and presence of guardianship.

Applications of Strain Theory to criminal behaviour suggest that offending is the product of personal strain and stressors. Disasters are thought to be an external stressor, which may result in increased offending. Ideas of increased stress from disasters have been a prominent explanation for an observed increase in domestic violence.

The ideas featured throughout Social Disorganisation Theory, Routine Activity Theory, and Strain Theory have been central to research on criminal behaviours during and following natural disasters and are thus used as a framework to explain the results of this work. Synthesising elements of these theories, the following hypotheses are made for this study:

- Crime will decrease in areas where communities are strong,
- Domestic violence will increase overall, but especially so in areas where disaster effects were worse,
- Crime (especially property crime) will increase in areas where communities were disrupted by disaster effects

Chapter 4 Method

4.1 Study design

This chapter outlines the method undertaken to analyse the temporal and spatial variability of crime in Christchurch before, during, and after the Canterbury Earthquakes. The analyses are divided into three distinct sections:

1. **Temporal analysis** – analyse the temporal trends of crime in Christchurch following the Canterbury Earthquakes.
2. **Spatio-temporal analysis** – identify significant changes in the spatial distribution of crime post-earthquake Christchurch.
3. **Regression analysis** – identify significant predictors of crime rate change in areas of Christchurch after the Canterbury Earthquakes.

Study period

This research covers a five year period beginning 1st July 2008 and ending 30th June 2013. This period contains five fiscal years (fiscal years being between 1st July and ending 30th June the following year), which were divided into three periods of activity: *pre-disaster* (first two fiscal years), *disaster* (the central fiscal year), and *post-disaster* (the last two fiscal years) (see Table 1). Dividing the timescale in this way allows for the isolation of the most significant events and aftershocks of the Canterbury Earthquakes into the central disaster period (between July 2010 and June 2011), as well as allowing for the analysis of both short- and moderate-term implications.

Table 1 Time period definitions in method

	Pre-Disaster	Disaster	Post-Disaster
<i>Date</i>	July 2008 to June 2010	July 2010 to June 2011	July 2011 to June 2013
<i>Years</i>	2	1	2
<i>Phase (NGA)</i>	'Mitigation' and 'Preparedness'	'Response' and 'Recovery'	'Recovery'

Pre-disaster

The first period, *pre-disaster* (1st July 2008 through 30th June 2010) covers two full fiscal years that pre-dates any form of significant seismic activity in the Canterbury region. This period serves as a control to the effects of the Canterbury Earthquakes representing “life as normal”. Reflecting on the NGA’s four stage model (identified in the introduction), this period is representative (in behaviour and processes) of the mitigation and preparedness phases.

Disaster

The central *disaster* period contains a single fiscal year between the pre- and post-disaster periods, (between 1st July 2010 and 30th June 2011) which contains the majority of the major earthquake activity of the Canterbury Earthquake sequence, including the Darfield and Christchurch Earthquakes. This period also represents the immediate effects of these earthquake events, and the associated period of disruption that followed, disruption that was constantly renewed by the occurrence of repeated aftershocks during this time, causing further damage and increased mental stress (Renouf, 2012). This period represents the response for Christchurch following the Canterbury Earthquakes.

Post-disaster

The final *post-disaster* period (1st July 2011 through 30th June 2013) covers two fiscal years that were largely unaffected by the most significant activity of the Canterbury Earthquakes. Devoid of most of the disruption and immediate effects of the Canterbury Earthquakes, the post-disaster period provides commentary on the moderate-term ramifications of the Canterbury Earthquakes on crime in Christchurch. Again raising the NGA’s model of disaster response, the post-disaster period represents the recovery phase in Christchurch and Canterbury, where the immediate effects of the disaster have now passed and the city and region face a long period of rebuilding. Christchurch has entered this ongoing state of recovery that will introduce substantial change in both physical and social conditions.

The division of the five year observation window into the three distinct study periods allows for a more clear delineation of the moderate-term temporal significance of the Canterbury Earthquakes on crime patterns. The central disaster period is excluded from the regression analysis, thereby avoiding the immediate short-term disruption caused by the Canterbury Earthquakes, when residents were most subject to abnormal social, psychological, and physical strains. Comparing the pre- and post-disaster periods, crime is compared in two

states of relative normality, before and after the Canterbury Earthquakes. The crime rates in each of these periods represent two-year averages, reducing the vulnerability of the method to data anomalies and extreme values.

Study location

This study focuses on the city of Christchurch, the largest urban area in the Canterbury region and the South Island of New Zealand. Located in central Canterbury, near the eastern coastline, Christchurch is built around a small urban city centre that immediately becomes less developed and suburban outside of the central city/CBD. For this analysis, the city of Christchurch is defined by six of the metropolitan council wards used by the Christchurch City Council (CCC). The CCC also presides over the large rural ward of Banks Peninsula, however this ward was excluded in an effort to limit the analysis to largely urban and suburban areas, and to avoid the vastly different criminal patterns common in rural areas (see Leitner et al., 2011).

Spatial resolution

The analysis in this study was carried out over a range of temporal and spatial resolutions. The initial temporal analysis was carried out for the entire city of Christchurch. The spatio-temporal analysis was performed at an event-level using Kernel Density Estimation. The regression analysis was performed using aggregate areas, which facilitated the creation of localised crime rates to be used in the regression modelling.

Administrative areas have frequently been applied in the observation and modelling of social phenomena, such as crime levels. These boundaries provide a broad representation of communities; a concept heavily cited throughout environmental criminology literature. Whilst communities are incredibly difficult to define and measure, made up of complex social networks rather than administrative boundaries, suburb-level boundaries provide the best available proxy of communities for this analysis (Sampson & Groves, 1989).

In this study, the Census Area Unit (CAU) was used as a unit of analysis. CAUs are the second finest resolution of boundaries used by the *New Zealand Census of Population and Dwellings* (NZ Census), with each CAU containing roughly 2300 inhabitants. Produced at five yearly intervals (with the exception of 2013), the NZ Census grants unparalleled access to

demographic information about New Zealand's population at sub-regional levels. Using variables derived from the NZ Census, post-earthquake changes in crime rates may be analysed and the cause of this change be examined using neighbourhood-level factors such as residential mobility and socioeconomic status. Whilst the use of Meshblocks (the finest resolution boundary available in the NZ Census) would have greatly enhanced the spatial resolution of the regression analysis, they are subject to a greater degree of confidentiality measures, restricting the amount of information available. Figure 6 shows the 116 CAUs within the city of Christchurch.

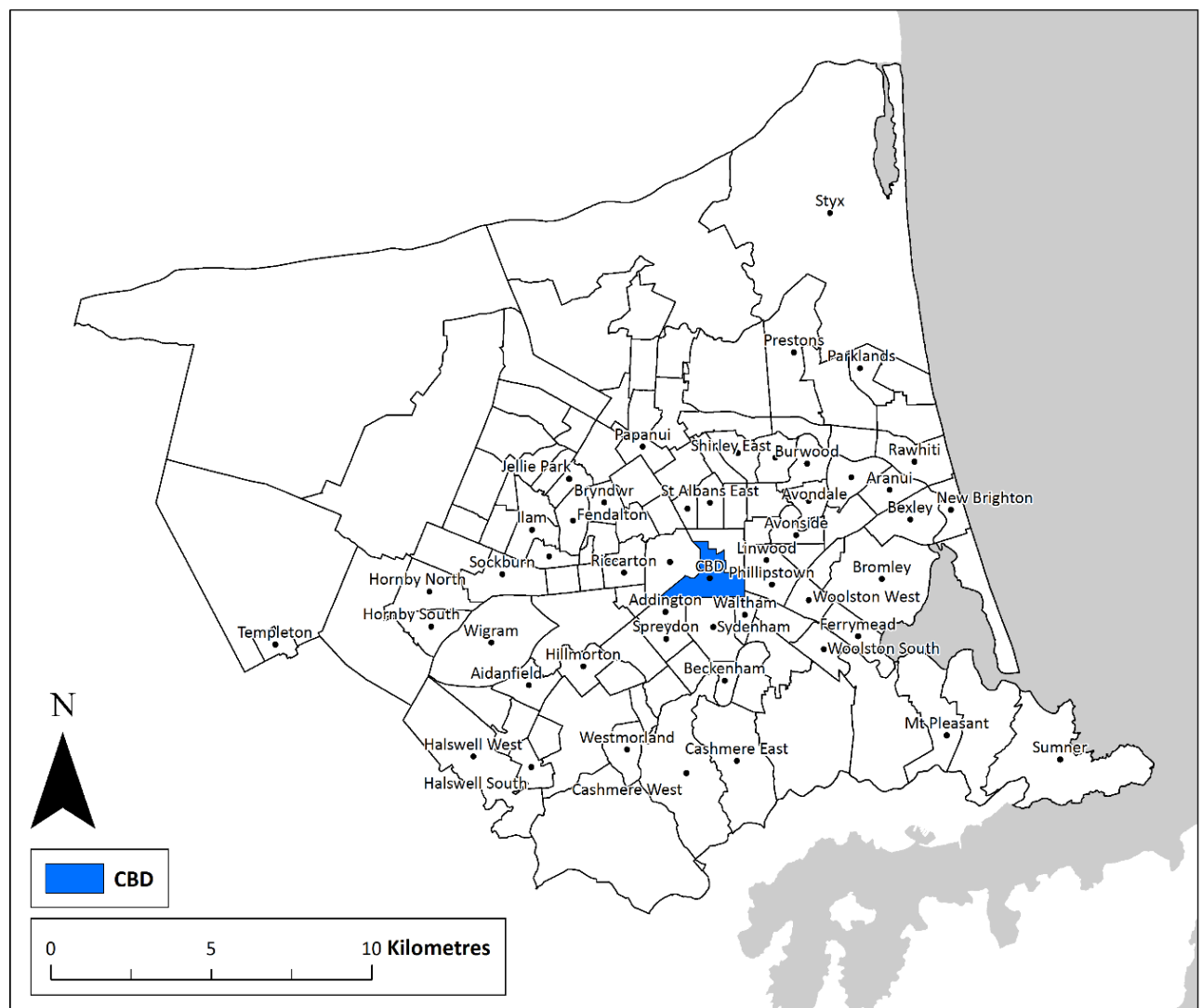


Figure 6 Map of Christchurch Census Area Units and prominent suburb names

Christchurch population

According to the 2013 NZ Census, Christchurch has a population of 333246, roughly eight percent of New Zealand's total population. This population is split 49 percent male and 51 percent female. In terms of age, Christchurch remains very close to national trends, albeit with a slightly higher percentage of 20 to 24 year olds (8.05 percent versus 6.97 percent for New Zealand). Christchurch had slightly lower proportions in the 5 to 9 and 10 to 14 age groups than national figures.

Comparing resident birthplace in Christchurch, New Zealand-born residents are overrepresented at 78 percent compared to 75 percent nationally, whilst overseas-born residents are underrepresented (22 compared to 25 percent nationally). Similar to national trends, the relative proportion of New Zealand-born residents decreased between the 2006 and 2013 NZ Censuses, while the percentage of overseas-born residents increased. The self-identified ethnicity of NZ Census respondents shows a substantially greater proportion of European residents and lower proportions of minority ethnicities compared to national figures (see Table 2).

Table 2 Ethnic composition of Christchurch population

	Christchurch		New Zealand	
	N	Percentage	N	Percentage
European	265,968	83.66 %	2,969,391	74.02 %
Maori	27,177	8.55 %	598,605	14.92 %
Polynesian	10,050	3.16 %	295,944	7.38 %
Asian	30,603	9.63 %	471,711	11.76 %
MELAA ¹	3,366	1.06 %	46,953	1.17 %
Other	6,105	1.92 %	67,752	1.69 %

¹ MELAA stands for Middle Eastern/Latin American/African

Population change

Figures from the NZ Census show a decrease in population in Christchurch of 7044 population (two percent) between 2006 and 2013. Considering that the most severe effects of the Canterbury Earthquakes occurred in late 2010 and early 2011, these figures provide only a limited indication of the population changes that coincided with the earthquake events. Counteracting some of the shortcomings of the NZ Census (such as non-respondents and five-yearly sampling), sub-national population estimates (referred to hereafter as population estimates) are created by Statistics New Zealand. These population estimates combine other available data (such as international travel documents and building consents) with the NZ Census to produce annual population estimates at various aggregate levels (Statistics New Zealand, 2011). Population estimates remain consistently higher than the NZ Census figures, taking into account the three month difference in observation, and census non-respondents.

Comparing estimates of Christchurch's population for June 2009 (363720) and June 2012 (346540) a population decrease of 17180 (approximately five percent) is observed. The disparity between population estimates (17180) and NZ Census figures (7044) suggests that the Canterbury Earthquakes had a far greater impact on population change than is evident in the NZ Census data (see Figure 7). These figures further indicate that the population of Christchurch rose until the onset of the Canterbury Earthquakes (in 2010), and subsequently dropped to its lowest point in 2012, before again resuming growth.

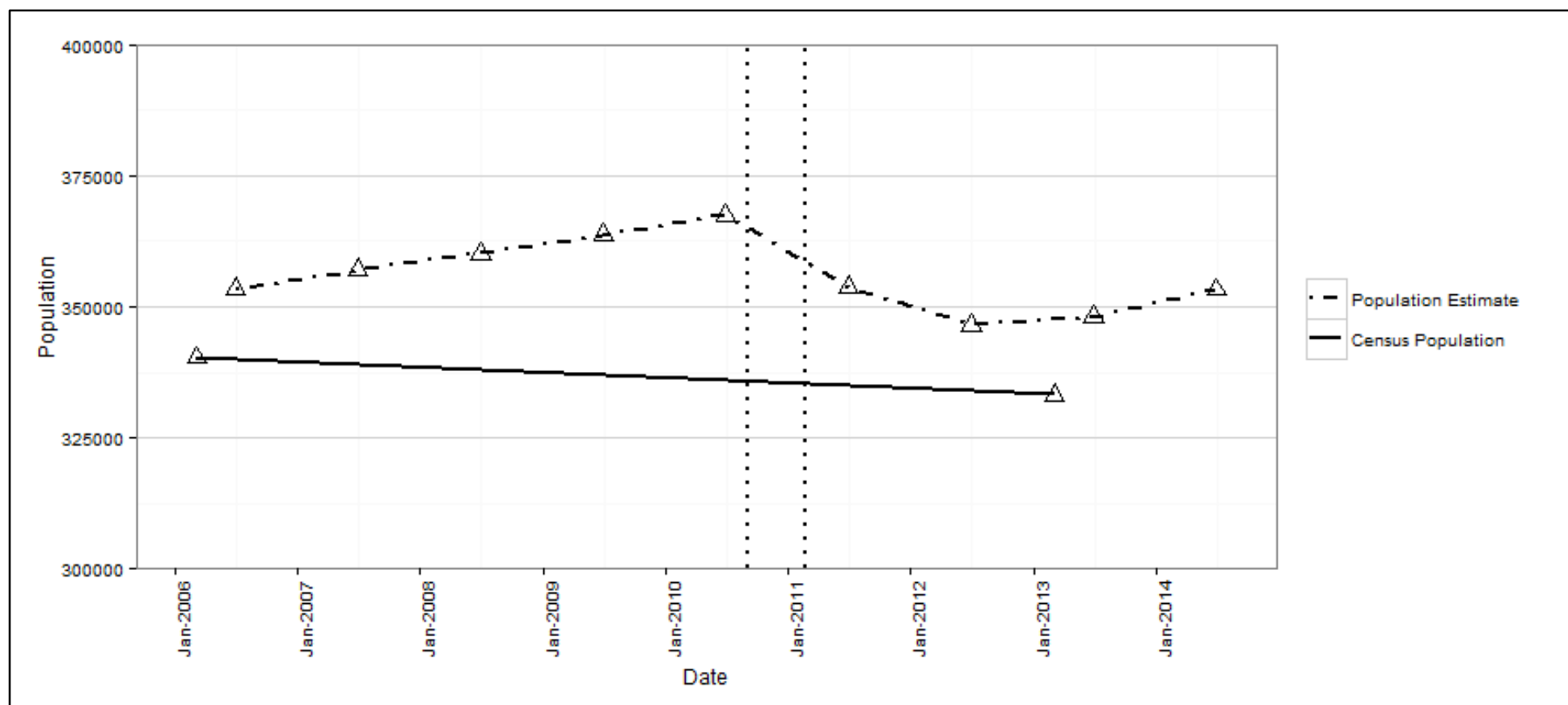


Figure 7 Comparison of NZ Census population data and population estimates, with the Darfield (September 2010) and Christchurch Earthquakes (February 2011) marked

Figures 8 and 9 show the spatial distribution of the Christchurch population in 2009 and in 2012 respectively. These represent the pre- and post-disaster periods. Figures 10 and 11 illustrate the differences between 2009 and 2012 population estimates more clearly, highlighting the spatial disparity in population changes across Christchurch before and after the Canterbury Earthquakes (Figure 10 is raw population change, whilst Figure 11 is the percentage change). In both maps, population decreases were most prominent in the CAUs where earthquake effects were the most severe, demonstrated by the coincidence of large population decreases with areas containing the Residential Red Zone (as depicted in Figure 5). Given that the Residential Red Zone is made up of where damage to homes was most prevalent, and where many homes necessitated demolition, this observation was not unexpected.

In some areas, populations nearly halved between the 2009 and 2012 estimates, as many residents moved away voluntarily, or were forcibly due to earthquake damage to their homes. Inversely population growth was apparent in western Christchurch, which became highly desirable for displaced residents and those migrating to the region. These westward CAUs received comparably minimal earthquake damage and became hubs for many amenities after the Canterbury Earthquakes. Furthermore, these western areas became popular sites for subdivision developments such as Wigram Skies and Aidanfield accommodating many new residents. To further highlight the extremity of post-earthquake population change in Christchurch, the top 10 CAUs for population growth and loss are shown in Tables 3 and 4 respectively.

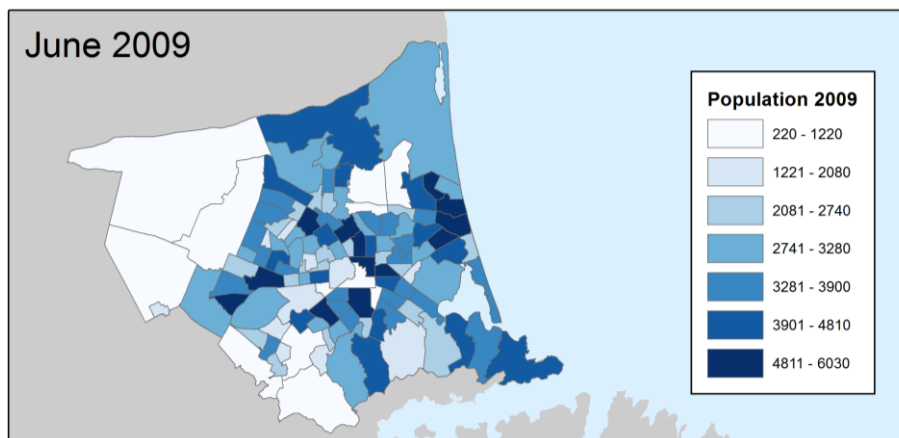


Figure 8 CAU level population estimates for June 2009

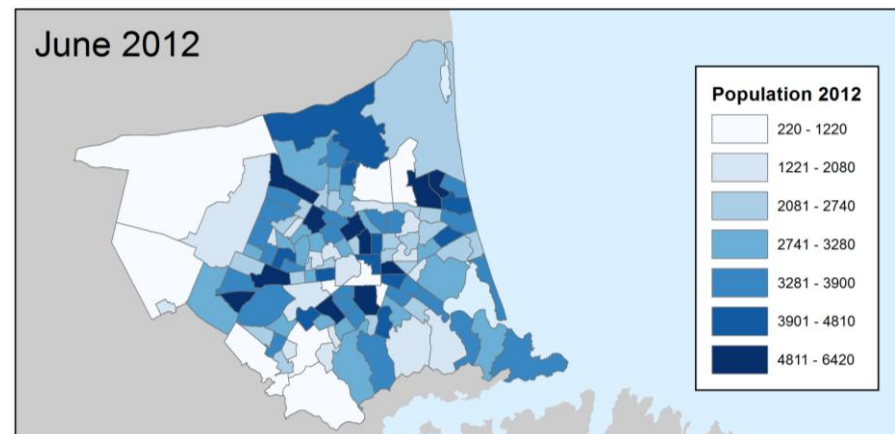


Figure 9 CAU level population estimates for June 2012

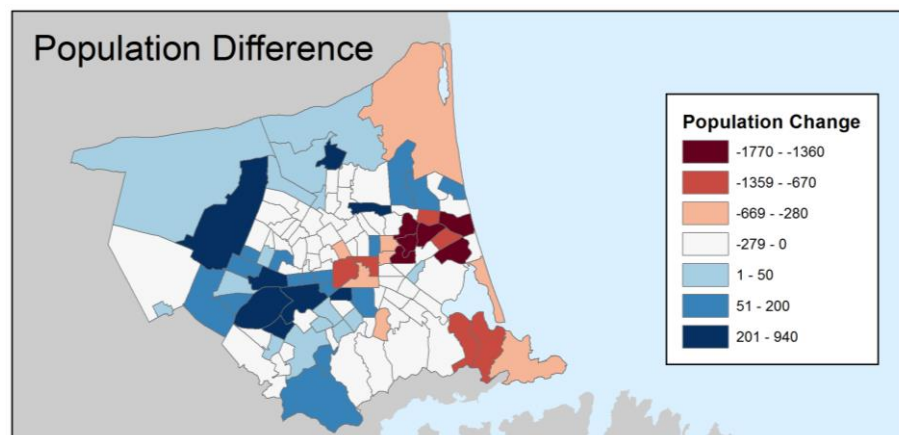


Figure 10 CAU level population change between 2009 and 2012

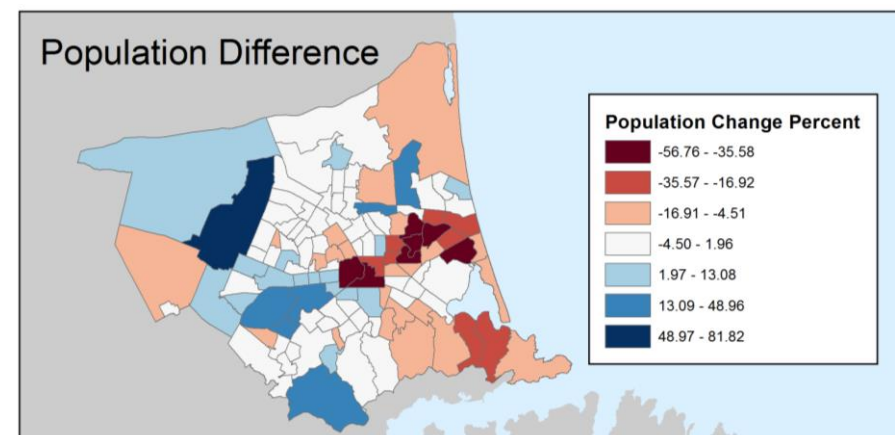


Figure 11 CAU level population change (percentage) between 2009 and 2012

Table 3 Ten CAUs with the highest population growth (2009-2012)

Rank	Population Percent Change	CAU Name
1	81.82 %	Yaldhurst
2	48.96 %	Aidanfield
3	32.37 %	Middleton
4	29.51 %	Mairehau North
5	27.27 %	Prestons
6	24.53 %	Kennedys Bush
7	19.60 %	Wigram
8	13.08 %	Belfast South
9	12.09 %	Addington
10	12.00 %	Riccarton South

Table 4 Ten CAUs with the highest population loss (2009-2012)

Rank	Population Percent Change	CAU Name
116	-56.76 %	Burwood
115	-44.62 %	Dallington
114	-42.61 %	Cathedral Square
113	-40.60 %	Bexley
112	-40.24 %	Avonside
111	-37.59 %	Avondale
110	-35.58 %	Hagley Park
109	-27.76 %	Travis
108	-26.33 %	Rawhiti
107	-23.60 %	Mt Pleasant

4.2 Crime in Christchurch

Given that the core objective of this research is to identify and understand changes in criminal behaviour and patterns, it is pertinent to examine past crime research in Christchurch (and New Zealand) in order to provide some context and a foundation against which changes can be compared and contrasted. Criminal research in Christchurch has focused on a number of specific crimes including burglary (see Davidson, 1980; A. M. Thornley, 2004) and sexual assault (see Pawson & Banks, 1993), as well as on the fear of crime (see Breetzke et al., 2013; Breetzke & Pearson, 2014; Conradson, 1996; Pawson & Banks, 1993). Compared to the breadth of criminal research in US (in particular), New Zealand has remained relatively unexplored in terms of criminal research and spatially-based crime research in particular.

Historically, overall crime in Christchurch (and indeed nationally) is low by international standards, and has a relatively high proportion of property crime compared to violent crime (see Breetzke et al., 2013). Pawson and Banks (1993) specifically noted that sexually-motivated crime was particularly rare in Christchurch, and as of the early 1980s was on the order of 100 offences per annum. Commenting on the nature of burglars, Davidson (1980) remarked that most are opportunist thieves taking advantage of discovered vulnerable targets, rather than professional criminals. Furthermore, Thornley (2004) identifies young unemployed European males, living in deprived areas as the most prominent burglars in Christchurch. Commenting on victimisation in Christchurch, Breetzke et al. (2013) cite New Zealand Europeans and males as the most frequent victims of crime, though Maori are disproportionately victimised. Notably, New Zealand's distinct ethnic composition provides a particular point of difference from other international crime research.

Spatial crime patterns in Christchurch have been observed with an east-west divide with generally higher crime rates in less affluent eastern suburbs (such as Linwood and Sydenham), and lower crime rates in more affluent western suburbs (such as Fendalton and St Albans) (Breetzke et al., 2013; Davidson, 1980; A. M. Thornley, 2004). A further trend has also been observed through a *central corridor* of high crime levels that runs through the central city, and includes areas such as Riccarton, Sockburn, Woolston, and Hagley Park (Breetzke et al., 2013; Davidson, 1980; A. M. Thornley, 2004). Pawson and Banks (1993) note a specific

clustering of violent sexual assaults in Hagley Park, and in the neighbourhoods immediately to the north and east of the central city.

The scant research that does exist for Christchurch indicates a number of potential causal crime associations that will be tested throughout this work. For example, deprivation, residential mobility, social fragmentation, ethnic heterogeneity, and youth populations have all shown positive significant relationships for both property and violent crime levels, whilst alcohol accessibility, Maori population, population density, and young male population have proven to be significantly associated with only violent crime (Breetzke et al., 2013; Davidson, 1980; Day, Breetzke, Kingham, & Campbell, 2012; Pawson & Banks, 1993).

4.3 Data

The primary dataset for this research was the New Zealand Police's (NZ Police) record of reported crime. This data provides the best available means of gauging the effects of the Canterbury Earthquakes on crime. Each reported offence is recorded with a time and location as well as a description and classification of the offence. All reported offences within the Canterbury Metro Police Area between 1st July 2008 and 30th June 2013 were provided by the NZ Police to complete this analysis.

Table 5 Definition of offence types

<i>Offence</i>	<i>Defined</i>
Assault	All acts classified under <i>assault, acts intended to cause injury, and attempted homicide</i> , inclusive of manual offences and the use of weapons. Domestic violence is excluded.
Domestic Violence	Acts of <i>common assault</i> , denoted as occurring in a domestic context.
Burglary	All acts classified as <i>unlawful entry with intent/burglary, break and enter</i> .
Arson	All acts classified as <i>property damage by fire or explosion</i> .

In this study I compared the spatial and temporal trends of four offence types; assault, domestic violence, burglary, and arson. The NZ Police data was classified in accordance with the Australian and New Zealand Society of Criminology's (ANZSOC) guidelines. The ANZSOC description of each type of offence type is provided in Table 5. To maximise the comparability of this research to past work, the four broad offence types studied were modified slightly from these ANZSOC classifications to more closely reflect the Part I Offences defined in the Federal Bureau of Investigation's (2004) (FBI) Uniform Crime Reporting guidelines. The FBI's offence definitions have been frequently used across many past works (Bass, 2008; Varano et al., 2010; Walker et al., 2012, 2014; Zahran et al., 2009).

These four crime types were selected based on their significance in previous disaster-crime studies, as well as in media coverage of the Canterbury Earthquakes. Violent crime has received relatively minor attention in disaster literature, though it has largely been observed

to decrease following a disaster (see Leitner et al., 2011; Zahran, Shelley, Peek, & Brody, 2009). Media reporting following the Canterbury Earthquakes have suggested a rise of violent crime in peripheral areas away from the central city (see Ensor, 2013, 2014; Lynch, 2011). In contrast to trends in violent crime, domestic violence has commonly been found to increase after a disaster (see Adams & Adams, 1984; Enarson, 1999; Zahran et al., 2009), a trend seemingly supported by local media (Carville, 2011; Lynch, 2011a; Stylianou, 2011). Property crime has been a major focus of disaster research with evidence of both post-disaster increase (see Leitner & Helbich, 2011; Walker et al., 2012, 2014) and decrease (see Barsky et al., 2006). Outside of theft- and burglary-type offences, other property crimes, such as arson, have received little attention in the extant disaster-crime literature. Both burglary and arson have received considerable media attention following the Canterbury Earthquakes for a perceived targeting of the Residential Red Zone (Gates, 2012; Heather & Lynch, 2012; Hume & Robinson, 2015).

For this analysis, assault is defined very broadly to include all forms of aggravated and common assault, assault with the use of weapons, assault on children and police officers, and attempted homicide. Though ANZSOC classifies attempted homicide under homicide, these offences were included under assault in this analysis to align the assault category to the FBI's definition that is nearly ubiquitous in international research. Given the general disparity in the trends observed for general violent crime and domestic violence (see Zahran et al., 2009), assault and domestic violence offences were separated to isolate any potentially unique trends. Domestic violence offences were identified by the inclusion of a domestic context in their description. Burglary and arson were simply defined using the ANZSOC Group Description of unlawful entry with intent/burglary, break and enter (burglary), and property damage by fire or explosion (arson). Limited by the time constraints of this analysis, theft, auto theft, vandalism, and public disorder offences were excluded, despite evidence of their relevance to this work (Ensor, 2014; Walker et al., 2012, 2014).

Offences were provided by the NZ Police with existing Northings and Eastings recorded for each offence. The provision of these coordinates eliminated the potential for error usually present in the geocoding of street addresses (such as address matching, database completeness, and non-addressed locations) (Cayo & Talbot, 2003; Chainey & Ratcliffe, 2005;

Goldberg, Wilson, & Knoblock, 2007; Rushton et al., 2006). Offences were spatially clipped in ESRI's ArcGIS to limit offences to those occurring within the bounds of Christchurch.

Table 6 Offence totals and percentages for Christchurch across the five year study period

	Pre-Disaster		Disaster	Post-Disaster		
Fiscal Year	1	2	3	4	5	Total
Assault	3068	3235	2890	2629	2879	14701 (31.4 %)
Domestic Violence	225	221	246	243	406	1341 (2.86 %)
Burglary	6019	5952	6023	4799	5034	27827 (59.44 %)
Arson	1028	675	571	375	299	2948 (6.3 %)
Total	10340	10083	9730	8046	8618	46817
	(22.09 %)	(21.54 %)	(20.78 %)	(17.19 %)	(18.41 %)	

Table 7 Offence totals and percentages for Christchurch in pre-disaster and post-disaster periods

	Pre-Disaster	-	Post-Disaster	Total
Assault	6303	-	5508	11811 (31.85%)
Domestic Violence	446	-	649	1095 (2.95%)
Burglary	11971	-	9833	21804 (58.79%)
Arson	1703	-	674	2377 (6.41%)
Total	20423	-	16664	37087
	(55.07%)	-	(44.93%)	

Tables 6 and 7 summarise the number and relative proportion of each of the four selected offence types. Within Christchurch between July 2008 and June 2013, a total of 46817 offences were included in the final dataset. The distribution of these offences between the four offence types was particularly uneven, divided between assault (31.4 percent), domestic violence (2.86 percent), burglary (59.44 percent), and arson (6.3 percent) (see Table 6). To compare differences in the offending between the pre- and post-disaster periods, the first two years, and the last two years were aggregated to represent the pre- and post-disaster periods, respectively, whilst the middle disaster period was removed (see Table 7). Overall the relative proportions of the four included offence types remain similar, though there is a clear decrease in offence numbers in the post-disaster period. A more in-depth descriptive analysis of offending is provided later.

As is necessary in any such analysis of crime, local and global crime rates were created to account for the heterogeneous distribution of population across the study area, thus permitting inter-CAU comparisons. Localised crime rates were created by spatially joining all offences in the NZ Police data to the NZ Census CAU boundaries. Annual crime rates (per 10,000 persons) were generated for each offence type and fiscal year between 2008/2009 and 2012/2013. For both the pre- and post-disaster periods (both two years in duration), two-yearly average annual crime rates were created. Crime rates were calculated for each CAU to allow for the analysis of localised variability across the city, whilst global crime rates for the entire city were also created to analyse large scale temporal patterns. Subsequently, localised crime rate change (per CAU) was calculated by subtracting the mean annual crime rate for the pre-disaster from that of the post-disaster period.

To account for the substantial population movement following the Canterbury Earthquakes from adversely affecting the accuracy of crime rates, population figures for each period (and CAU) were derived from the Statistics New Zealand's population estimates. The use of moving population estimates in crime rate calculation, were highlighted in research after Hurricane Katrina to account for the substantial population change occurring there (Leitner et al., 2011). As discussed earlier, the Statistics New Zealand estimates provide the best available indication of resident population at an annual interval. Population estimates for 2009 and 2012 were used to normalise pre- and post-disaster (respectively) crime totals, whilst the average of the 2010 and 2011 estimates were used to create the disaster period crime rates.

Dependent variables

Two sets of dependent variables defining crime rate change were constructed for use in the regression analysis. Leitner and Helbich (2011), and Walker et al. (2012, 2014) followed a conceptually similar method, analysing localised changes in the crime densities after a disaster to that prior. These researchers used regression analysis to identify associations between neighbourhood-level characteristics and areas that experienced abnormal changes in crime levels post-disaster. The regression modelling analysis in this research builds on the ideas of these prior works through the establishment of an adjusted measure of localised crime rate change in the moderate-term.

Past analyses of disaster-related changes have varied considerably in timeframe and study period, from week-to-week (Varano et al., 2010), month-to-month (Leitner et al., 2011), and year-to-year (Bass, 2008; Zhou, 1997). In their works, Leitner and Helbich (2011), and Walker et al. (2012, 2014) compared crime patterns mere days apart to capture and understand the immediate effects of disasters on crime. This research offers an alternate perspective to this same research idea, comparing post-disaster variations in crime outside of the initial disaster period (as detailed earlier). By comparing crime using rates developed from two year periods, the effects of data anomalies, which would be expected in the immediate disaster period, and daily, weekly, and seasonal variations are lessened. More specifically, this research compares a two year pre-disaster period (prior to any seismic activity) with a two year post-disaster period (subsequent to most of the major earthquake events).

Given that the two periods of comparison in this research are substantially longer than Leitner and Helbich's (2011), and Walker et al.'s (2012, 2014) similar works, adjustment was required to account for the natural change in crime rates that may have occurred in the absence of the disruptive effects of the Canterbury Earthquakes (see Lee, 2010; Varano et al., 2010). Accordingly, two sets of dependent variables were developed for each of the four offence types (assault, domestic violence, burglary, and arson); a multinomial variable, the *mean classification*, and a binary variable, the *natural classification*. Using these two classification methods (as detailed below), two sets of categorical dependent variables were created by categorising localised changes in crime rate (as detailed earlier). The use of a categorical variable simplified the analysis, eliminating many of the issues that are often experienced in

empirical uses of continuous dependent variables, such as the requirement for non-skewed normal distributions.

The first set of categorical dependent variables, referred hereafter as the *mean classification*, were calculated by identifying whether the crime rate change for a given CAU was above the mean change (2), similar to the mean change (1), or below the mean change (0) for Christchurch as a whole. The change in crime rate in each CAU was compared to the average for the city in an effort to identify whether these localised changes were in-line with the city's general trend (near normality), or substantially greater or less than it (and thus of interest). The inclusion of the central 'similar to the mean' category allowed for natural fluctuations in crime rate change that would be expected even when using two-year annual averages, and preventing the misrepresentation of changes near to this mean figure. Given a lack of similar adjustments in past disaster-crime research, an arbitrary value (ten percent of one standard deviation) was used to determine the values used for categorisation. For each offence type, this value was added to the mean to establish the upper bound, and subtracted from the mean to establish the lower bound (see Figure 12). Using these two boundaries, each CAU (for each offence type) was categorised as being above the upper bound, below the lower bound, or between the two.

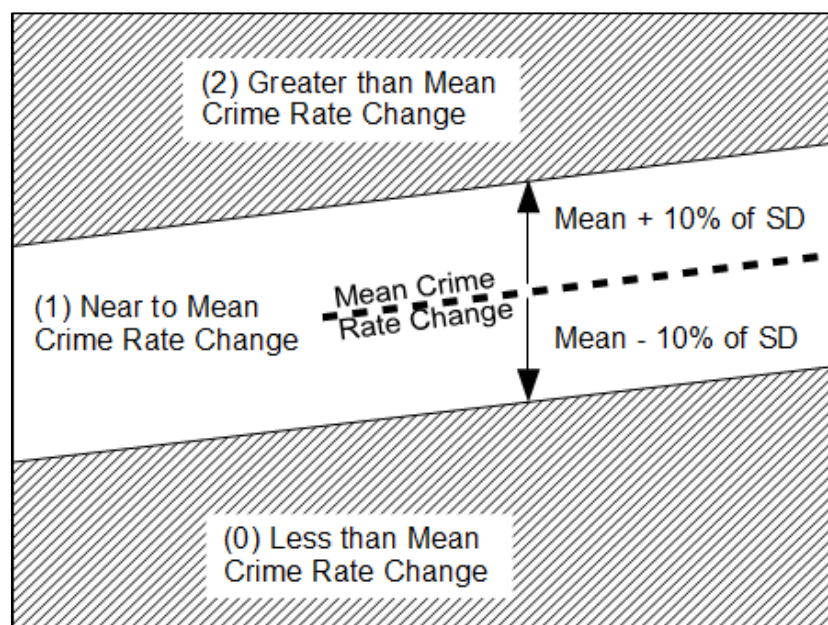


Figure 12 Method of calculating mean classification dependent variables

The second set of categorical dependent variables, referred hereafter as the *natural classification*, were determined by whether or not the crime rate change in each CAU was

above (1), or below (0) the natural crime rate change observed prior to the Canterbury Earthquakes. This method provides an explicit consideration of the change in crime rates that were being experienced prior to the onset of the Canterbury Earthquakes, projecting these to identify the expected trend in crime rates for that CAU. This was accomplished by calculating the change between the annual crime rates (for each offence) for the 2008 and 2009 fiscal years that completely pre-dated any of the effects of the Canterbury Earthquakes. This rate of change was then projected to establish what the crime rate would have been at the same time that the post-disaster annual average crime rate was calculated for. Each CAU was subsequently classified based on the observed crime rate being above or below this projected figure, thus approximately isolating the influence that the Canterbury Earthquakes had on crime rate change (see Figure 13). Given that this method only considered data from the two years prior to the Canterbury Earthquakes, it would have been preferable to have interpolated this trend from a longer period to better approximate longer-term trends.

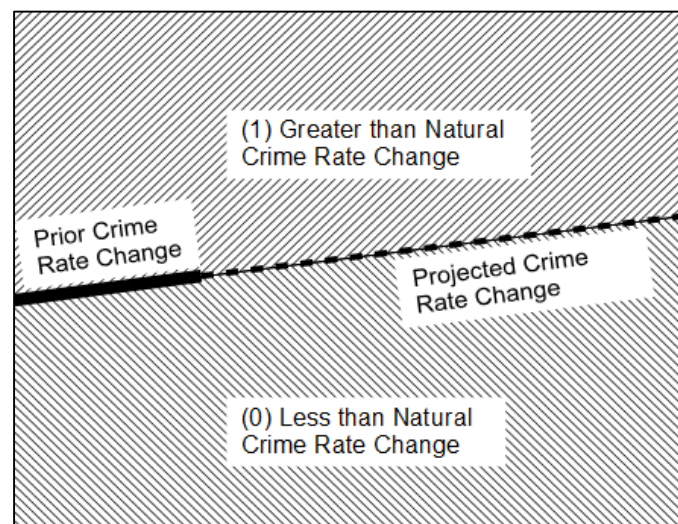


Figure 13 Method of calculating natural classification dependent variables

In applying this more comprehensive method of analysing post-disaster changes in crime rate, the meaning of the dependent variables and their interpretations is made more complex than more typical regression analyses. The dependent variables represent relative increases and decreases in crime rates, relative to the city's average (mean classification) or to the projected natural crime rate change (natural classification). Caution must be taken as these variables do not describe absolute change in crime rates and cannot be interpreted as such. In accounting for pre-existing or natural crime rate change the dependent variables instead describe

whether the actual crime rate change was above or below what would have been expected in the absence of the Canterbury Earthquakes over the same time period. For example, in an area with the construction of a new subdivision, it would be expected for crime rates to rise as the number of potential targets rises. Without accounting for such pre-existing trends in crime rates, increases or decreases in crime rates may be wrongly attributed to the disaster (in this case the Canterbury Earthquakes), when in fact these changes would have occurred regardless due to these pre-existing trends.

Independent variables

21 independent variables were created to represent various aspects of the theoretical frameworks outlined earlier. The use of various neighbourhood-level variables to predict the spatial variation of crime is frequently employed throughout environmental criminology. Shaw and McKay's (1942) Social Disorganisation Theory provided the key theoretical framework in this study with the idea that aggregate-level measures of social phenomena may be representative of the individual social and community processes that produce variation in crime rates. Previous criminal research in New Zealand has identified significant relationship between various measures related to social disorganisation, including deprivation, residential mobility, social fragmentation, and ethnic heterogeneity, and the distribution of crime hotspots (Breetzke et al., 2013; Davidson, 1980; Day et al., 2012; Pawson & Banks, 1993).

Social Disorganisation Theory and its core ideas have seen frequent application throughout disaster-crime research, specifically in how disasters are thought to affect concepts of social disorganisation, community altruism, disaster-induced vulnerability, and increased mental stress (for example Cromwell et al., 1995; Leitner & Helbich, 2011; Siegel et al., 1999; Watanabe & Tamura, 1995; Zahran et al., 2009). This research tests typical measures of social disorganisation to realise any present relationships that may relate a community cohesion to its ability to affect and control criminal behaviours.

Factors such as low socioeconomic status, high proportions of rental properties, ethnically and/or economically heterogeneous populations, large proportions of single parent families, and low organisational participation (Kubrin & Stewart, 2006; Sampson & Groves, 1989; Shaw & McKay, 1942), have all served as indicators of poor community cohesion and the resultant presence of social disorganisation in communities. These same ideas of social disorganisation and community cohesion have been proposed as influencing criminal trends after a natural disaster, either in a community's ability to control increased offending (see Davila et al., 2005; Siegel et al., 1999), or with a disaster's effects leading to the destabilisation of these communities (see Bass, 2008; Leitner & Helbich, 2011; Varano et al., 2010).

Socioeconomic status

Often the first variable considered in similar analyses, the association between lower socioeconomic status and increased social disorganisation has frequently been drawn by researchers (Sampson & Groves, 1989; Shaw & McKay, 1942). Considering the implications of socioeconomic status on personal resilience after a disaster, Munasinghe (2007) propose two theories. First, that the poor may be more severely affected by disaster effects (e.g. living in poorly constructed homes), and second that the poor may be more resilient to disaster-induced hardships (e.g. shortages of food and water, and the loss of electricity). As such, a variety of socioeconomic-related variables were constructed and tested for significance against post-earthquake crime rate change.

The first such measure calculated was *median family income per CAU*. This was sourced from the 2013 NZ Census and served as a very basic and generalised measure of an area's affluence and socioeconomic status. A measure of *unemployment* was also included given its past significance in previous associations with burglary in Christchurch (see Davidson, 1980; Thornley, 2004), and as a further indicator of socioeconomic status. Unemployment was measured as the percentage of respondents in the 2013 NZ Census reporting being unemployed.

The *New Zealand Deprivation Index (NZDep)* provides a more comprehensive means of evaluating the socioeconomic status of an area. The NZDep has been a frequent inclusion in past research of crime distribution in New Zealand (Breetzke et al., 2013; Day et al., 2012; A. M. Thornley, 2004). The index was designed and constructed by the Department of Public Health – University of Otago by combining nine variables collected in the NZ Census that represent deprivation in an area (Atkinson, Salmond, & Crampton, 2014) (as listed in Table 8). The NZDep serves as a general indicator of not only socioeconomic status and relative affluence, but also for the access of opportunities by that area's residents. Due to the overlap with other independent variables defined here, I acknowledge the importance of their exclusion when using the NZDep as to prevent the presence of multicollinearity.

Table 8 Variables making up 2013 NZDep (sourced from Atkinson et al., 2014)

Dimension of deprivation	Description of variable (in order of decreasing weight in the index)
Communication	People aged <65 with no access to the Internet at home
Income	People aged 18-64 receiving a means tested benefit
Income	People living in equivalised* households with income below an income threshold
Employment	People aged 18-64 unemployed
Qualifications	People aged 18-64 without any qualifications
Owned home	People not living in own home
Support	People aged <65 living in single parent family
Living space	People living in equivalised* households below a bedroom occupancy threshold
Transport	People with no access to a car

*Equivalisation: methods used to control for household composition.

Index of Concentration at the Extremes

The *Index of Concentration at the Extremes (ICE)* is a measure of economic inequality developed by Massey (2001). The measure considers the relative proportions of affluent and poor families living in the same neighbourhood and is calculated using the equation below:

$$ICE = \frac{Affluent\ Families - Poor\ Families}{Total\ Families}$$

Morenoff et al. (2001) define affluent families as those earning in excess of \$50,000, and impoverished families as those with incomes below the poverty line. Given the availability of income-based data in the NZ Census, three ICE variables were constructed, each with a differing definition of poverty as New Zealand does not officially define a poverty line. I acknowledge that this variable will likely differ to uses in countries due to disparities in economic states, and average and expected income.

ICE [1] with poverty defined as a family income less than \$20,000:

$$\frac{Family\ Income > 100k - Family\ Income < 20k}{Total\ Families}$$

ICE [2] with poverty defined as a family income less than \$30,000

$$\frac{\text{Family Income} > 100k - \text{Family Income} < 30k}{\text{Total Families}}$$

ICE [3] with poverty defined as a family income less than \$50,000

$$\frac{\text{Family Income} > 100k - \text{Family Income} < 50k}{\text{Total Families}}$$

Family cohesion

Family cohesion was measured as the *proportion of single parent households in a CAU*. Sampson (1987) suggested divorced families are less able to influence and control the behaviour of youths.

Residential mobility

Increased *residential mobility* (less stable populations) is thought to lessen attachment to local communities, thus preventing social and community bonds from forming (Kornhauser as cited in Sampson & Groves, 1989). Previous research both in New Zealand and internationally has generally supported the association between higher residential mobility and greater offending (Breetzke et al., 2013; Breetzke & Pearson, 2013; Davidson, 1980; Walker et al., 2012). Replicating Breetzke and Pearson's (2013) measure of residential mobility, each CAU was assigned a percentage of the residents who had lived at that residence for less than five years. Considering the sizeable population change that has occurred in Christchurch since the Canterbury Earthquakes, this measure will capture both areas with higher population turnover as a result of rental properties (as opposed to owner-occupied residences), but also areas where new residents have settled (either from intra-city movement, or from national or international origins).

$$\frac{\text{Years at Residence [0]} + \text{Years at Residence [1 - 4]}}{\text{Total Respondents}}$$

Ethnic heterogeneity

The third and final factor of Shaw and McKay's (1942) original Social Disorganisation Theory was ethnic heterogeneity. High ethnic heterogeneity, where minority ethnic groups are relatively more prevalent, is thought to inhibit community connections and reduce the ability of communities to realise shared values (Sampson & Groves, 1989; Shaw & McKay, 1942). Hipp (2007) suggests that high ethnic heterogeneity also promotes crime as a result of inequalities in opportunities and socioeconomic status of different ethnic groups, made ever

apparent by their cohabitation. Most previous considerations of ethnic heterogeneity have been limited to the relative populations of Caucasian and African Americans in a given area. In New Zealand, population compositions differ markedly to the US, and consequently alternate measures of ethnic heterogeneity were sought. New Zealand-specific measures of ethnic heterogeneity, and the proportionate population of Maori, have shown a relationship with higher levels of violent and property offending (Breetzke et al., 2013; Day et al., 2012). Accordingly, *two measures of ethnic heterogeneity and composition were created*. The first measure utilised in this study was taken from Breetzke et al. (2013), and Breetzke and Pearson (2013), who defined ethnic heterogeneity in New Zealand by the equation below:

$$\text{Percentage Maori} * \text{Percentage Non Maori}$$

A second, more simplistic measure was also calculated measuring ethnic heterogeneity as a percentage of resident ethnic minorities living in an area.

$$\frac{\text{Pop [Maori]} + \text{Pop [Pacific Islander]} + \text{Pop [Asian]} + \text{Pop [MELAA]} + \text{Pop [Other]}}{\text{Total Population}}$$

Note: MELAA represents the combination of Middle Eastern, Latin American, and African ethnic groups.

Collective efficacy

Sampson and Groves (1989) theorise that the level of involvement in one's community aids in the development of social and community bonds, and that this promotes social organisation and collective efficacy. Sampson and Groves (1989) found a negative effect on crime levels in areas where residents were more highly involved in local community meetings and groups. Collective efficacy was operationalised using two measures: the first considered the *proportion of persons involved in some form of volunteer activities*.

$$\frac{\text{Volunteer Work}}{\text{Total Respondents}}$$

The second, considering those partaking in volunteer work as well as those reporting *time spent taking care of children, and unwell and/or disabled persons outside of their own household*.

$$\frac{\text{Care of Child} + \text{Care of Ill or Disabled} + \text{Volunteer Work}}{\text{Total Respondents}}$$

Other variables

Building on past theories and discussions around the effects that natural disasters have had on affected populations, four measures of disaster-related effects were created for use in this study.

Earthquake damage

The first two variables provide a measure of the severity of earthquake damage experienced in each CAU. This done to test assertions that burglary may be more prone in areas experiencing greater disaster damage (see Cromwell et al., 1995; Gray & Wilson, 1984; Watanabe & Tamura, 1995; Zhou, 1997). Furthermore, suggestion of increased burglary and arson in Christchurch areas suffering greater earthquake damage has been prominent in local media (Gates, 2012; Heather & Lynch, 2012; Hume & Robinson, 2015).

A proxy for earthquake damage was compiled by *comparing the number of occupied dwellings in a CAU for the 2006 and 2013 censuses*. Where earthquake damage was most severe, demolition was often required. As such, a lack of new dwellings and the reduction in dwelling number are generally indicative of earthquake damage-related demolition.

$$\frac{\text{Occupied Dwellings 2013} - \text{Occupied Dwellings 2006}}{\text{Occupied Dwellings 2006}}$$

An alternative measure of disaster effects per CAU was created by calculating *the percentage of land area in each CAU occupied by the Residential Red Zone*. These are areas deemed uninhabitable by CERA after extensive structural assessments of all properties after the Canterbury Earthquakes. Using the spatial areas of the Residential Red Zone provided by CERA, the Red Zone was segmented in ArcGIS (using the Split Tool) and spatially joining to each CAU to produce the proportion of each CAU that contained the Red Zone. In total, 26 CAUs in Christchurch contained some area of the Residential Red Zone, with the highest amount being just under 47 percent of its total land area (Dallington).

Earthquake-related immigration

A measure of immigration and population change following the Canterbury Earthquakes was created to test the possible influence of migrant workers arriving in Christchurch on crime. Previous research has been completed on such post-disaster population movement with mixed findings (Bass, 2008; Leitner et al., 2011; Varano et al., 2010). More specifically, the

post-disaster arrival of workers for disaster-related employment, such as for the repair of damaged homes, has been previously linked to post-disaster criminal offending both internationally (see Cromwell et al., 1995; Davila et al., 2005) and in Christchurch (see Dally, 2013b). As such, a measure of the *change in overseas born residents* was created, gauging increases and decreases in the relative proportions of foreign born residents.

$$\frac{\text{Birthplace Overseas 2013}}{\text{Total Respondents 2013}} - \frac{\text{Birthplace Overseas 2006}}{\text{Total Repsondents 2006}}$$

Alcohol Accessibility

Alcohol has proven significant in predicting violent crime rates in New Zealand (see Breetzke et al., 2013; Day et al., 2012), has been associated with post-disaster violent offending (see Cromwell et al., 1995; Siman, 1977). The availability of alcohol has also been suggested by the media as one source of localised increases in violent crime after the Canterbury Earthquakes (see Ensor, 2013, 2014; Lynch, 2011b). This significance has thus led to the inclusion of measures of alcohol accessibility, hypothesising that some association may be present between the ease at which alcohol may be obtained and increased violent crime after the Canterbury Earthquakes.

Measures of alcohol accessibility were constructed using data provided by the Ministry of Justice of all alcohol licenses (necessary for the sale of alcohol) issued in Christchurch as of 2014. The 786 addresses of all licensees were geocoded using the Google Maps API with an approximate hit-rate of 90 percent, which was increased to 99% with manual additions. Six variables were constructed using three subsets: on-licenses (for example bars and restaurants), off-licenses (for example supermarkets and bottle stores), and the sum of both; each normalised to the land area (density in square kilometres), and population (per 10,000 people) to create six alternate measures of alcohol accessibility. The testing of alternate measures will allow for the delineation of specific associations with bar hotspots, or the accessibility of alcohol through stores.

The descriptive statistics for the list of independent variables used in the study are provided in Table 9 while Table 10 shows a correlation matrix examining the relationship between all independent variables.

Table 9 Descriptive statistics of independent variables

	Maximum	Mean	Median	Minimum	Standard Deviation
NZDep	1170	972.612	964	881	60.413
Median family income	150000	78813.793	78050	45600	18469.697
% Unemployed	9.286	3.433	3.156	1.282	1.35
ICE [1]	0.669	0.26	0.266	-0.081	0.163
ICE [2]	0.646	0.187	0.196	-0.201	0.189
ICE [3]	0.571	0.021	0.032	-0.453	0.226
% Single parent families	36.471	17.282	16.404	5	6.783
Residential mobility	0.689	0.47	0.501	0.131	0.111
Ethnic heterogeneity [1]	2211.465	832.662	739.572	194.906	407.816
Ethnic heterogeneity [2]	0.467	0.236	0.223	0.054	0.095
% Unpaid service	50	38.203	38.248	25.117	5.227
% Volunteering	23.81	13.791	13.596	7.801	2.832
% Occupied dwelling change	130.303	0.576	-0.457	-63.684	26.291
% Red Zone	46.934	2.663	0	0	8.693
% Change in foreign born	9.906	0.999	0.827	-13.41	3.085
Alcohol outlet density [on]	32.127	2.51	0.775	0	4.81
Alcohol outlet rate [on]	1297.405	25.615	6.223	0	122.144
Alcohol outlet density [off]	7.256	0.98	0.55	0	1.352
Alcohol outlet rate [off]	319.361	9.075	3.369	0	30.422
Alcohol outlet density [on & off]	37.634	3.49	1.294	0	5.978
Alcohol outlet rate [on & off]	1616.766	34.69	9.53	0	152.041

Table 10 Bivariate correlation analysis of independent variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.
1. NZDep	1																				
2. Median family income	-.822**	1																			
3. % Unemployed	.853**	-.687**	1																		
4. ICE [1]	-.897**	.960**	-.775**	1																	
5. ICE [2]	-.899**	.960**	-.777**	.997**	1																
6. ICE [3]	-.893**	.965**	-.759**	.995**	.997**	1															
7. % Single parent families	.911**	-.787**	.749**	-.851**	-.855**	-.859**	1														
8. Residential mobility	-.456**	.338**	-.577**	.383**	.386**	.356**	-.262**	1													
9. Ethnic heterogeneity [1]	.821**	-.689**	.608**	-.764**	-.758**	-.757**	.794**	-0.117	1												
10. Ethnic heterogeneity [2]	.769**	-.705**	.759**	-.779**	-.777**	-.760**	.651**	-.580**	.592**	1											
11. % Unpaid service	-.425**	.457**	-.437**	.477**	.478**	.453**	-.219*	.713**	-.236*	-.669**	1										
12. % Volunteering	-.637**	.680**	-.487**	.691**	.684**	.674**	-.541**	.435**	-.641**	-.600**	.736**	1									
13. % Occupied dwelling change	-.273**	0.127	-.311**	0.167	0.162	0.165	-.294**	-.191*	-.250**	-0.046	-0.181	-0.048	1								
14. % Red Zone	.192*	-0.165	0.12	-0.18	-0.171	-.186*	.201*	0.109	.220*	-0.002	0.147	0	-.445**	1							
15. % Change in foreign born	0.099	-0.12	-0.053	-0.124	-0.112	-0.115	0.077	-.198*	0.03	0.133	-0.127	-0.144	.380**	-0.092	1						
16. Alcohol outlet density [on]	.184*	-0.127	.410**	-0.172	-0.173	-0.144	0.059	-.565**	-0.07	.311**	-.446**	-.202*	-0.172	-0.097	-0.181	1					
17. Alcohol outlet rate [on]	0.079	-0.008	.411**	-0.061	-0.061	-0.036	-0.04	-.377**	-0.013	0.128	-.244**	-0.154	-.193*	-0.049	-.385**	.620**	1				
18. Alcohol outlet density [off]	.289**	-.224*	.458**	-.285**	-.284**	-.259**	0.16	-.526**	0.046	.345**	-.463**	-.293**	-0.154	-0.1	-0.119	.828**	.512**	1			
19. Alcohol outlet rate [off]	0.09	-0.016	.408**	-0.082	-0.081	-0.054	-0.041	-.350**	0.001	0.122	-.245**	-0.165	-0.169	-0.06	-.356**	.594**	.978**	.559**	1		
20. Alcohol outlet density [on & off]	.214*	-0.153	.434**	-.203*	-.204*	-0.174	0.084	-.574**	-0.046	.329**	-.463**	-.229*	-0.173	-0.101	-0.172	.992**	.615**	.893**	.605**	1	
21. Alcohol outlet rate [on & off]	0.082	-0.01	.412**	-0.066	-0.065	-0.04	-0.04	-.373**	-0.01	0.128	-.245**	-0.157	-.189*	-0.052	-.381**	.617**	.999**	.524**	.986**	.615**	1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

4.4 Temporal analysis

A range of temporal plots were generated in R to observe fluctuations in crime rates across the four studied offence types over the observation period. The plotting of these city-wide trends is essential in order to examine both the short- and long-term temporal trends in Christchurch over this disaster period. In plotting each offence type separately, any inter-offence variation in temporal trends can be examined.

A series of longitudinal plots were created to track offending patterns on a city-wide scale for Christchurch. These crime totals were normalised to three population estimates, representing the pre-disaster, disaster, and post-disaster periods, accounting for population change over the study period. A longitudinal plot of monthly crime rates (for assault, domestic violence, burglary, and arson) was generated for the entire five year observation period to observe fluctuations in crime at a moderate temporal resolution. Daily crime rates for the 28 days either side of the two major earthquake events; the Darfield Earthquake (4th September 2010) and the Christchurch Earthquake (22nd February 2011), were plotted to identify the immediate short-term effects of these events on crime. Finally, temporal profiles (the day of the week and time of the day for the offence) were created for each offence type and study period, allowing for an examination of whether the temporal characteristics of crime changed during or following the Canterbury Earthquakes.

4.5 Spatio-temporal analysis

Kernel Density Estimation (KDE) has been a popular spatial analysis technique used to visualise the spatial distribution of phenomena such as crime by interpolating a continuous density surface from vector data (Chainey & Ratcliffe, 2005). Leitner and Helbich (2009), and Leitner and Stauersteinnocher (2001) detail the process KDE as follows. A circular kernel function is applied over each feature in accordance with a nominated search radius. These functions are then summed and aggregated to a further layer (usually a regular grid but irregular polygons may also be used), to produce a continuous surface of event density values, highlighting any present hot and coldspots.

A further application of KDE has been the comparison of two density layers (occupying the same spatial location) to create a single layer illustrating the differences between the two, a technique called Dual Kernel Density Estimation (DKDE). DKDE has been applied in disaster-crime research as a means to compare crime distributions between two time periods, with one layer representing a period prior to the disaster, and the other layer representing a time during or after the disaster (Leitner & Helbich, 2011; Walker et al., 2012, 2014).

In this study, KDE and DKDE were utilised to examine the spatial distribution of crime in Christchurch, and compare how this distribution may have changed in the moderate-term, using DKDE to compare offending in the pre- and post-disaster period. In using two, two-year periods of offending, short-term variations in distribution are ignored, and the moderate-term changes in spatial patterning can more readily be identified.

Using ESRI's ArcGIS, a Python script was created to produce DKDE layers for each offence type (assault, domestic violence, burglary, and arson). The workflow generated KDE layers for each offence type for the pre- and post-disaster periods using the ArcGIS Kernel Density tool, set to a 25 metre output resolution, with a 700 metre search radius, and a quadratic kernel function. The Raster Calculator tool then compared the surfaces for each offence type, subtracting the pre-disaster density surface from the post-disaster surface. The resultant layers illustrate the how the spatial distribution of offending in the post-disaster period differs from pre-disaster Christchurch. Large positive values indicate that post-disaster offending in this area is greater than it was pre-disaster, and inversely negative values indicate that offending is lower than pre-disaster. Values approaching zero show that offending is of a similar magnitude across the two periods.

4.6 Regression modelling

In the final part of the method, logistic regression analysis is applied to determine the influence of neighbourhood-level variables in predicting crime rate change following the Canterbury Earthquakes. Regression analysis is a statistical technique with a range of applications, and has frequently been used in spatial crime research. The use of regression has varied substantially in disaster-crime research, including in the analysis of temporal trends in offending (see Bass, 2008; Leitner et al., 2011; Varano et al., 2010), and post-disaster victimisation (see Gray & Wilson, 1984; Siegel et al., 1999). The use of regression in this work is based around the ideas put forth by Leitner and Helbich (2011), and Walker et al. (2012, 2014), who used regression to identify relationships between neighbourhood-level characteristics and areas which saw increased or decreased offending during disasters compared to times of normality. In the same vein, regression is used here to identify relationships between neighbourhood-level characteristics and moderate-term changes in offending in Christchurch.

Logistic regression was applied to test the associations between numerous neighbourhood-level independent variables and the two sets of categorical dependent variables (eight variables in total). Logistic regression was used in this work, over more common linear regression models, as it enabled crime rate change to be analysed in a more isolated approach, reducing the influence of shorter-term fluctuations and longer-term trends in crime (see Dependent Variables). Unlike other linear regression techniques, logistic regression models utilise categorical dependent variables. In the case of this work (and as defined under Dependent Variables) the dependent variables represent two differing perspectives of crime rate change after the Canterbury Earthquakes. The first categorising CAUs as experiencing above or below average crime rate change (a multinomial variable with three outcomes), and the second as experiencing greater or less than the crime rate change observed before Canterbury Earthquakes (a binary variable with two outcomes).

Eight regression models were developed in total, four using multinomial logistic regression and the other four using binomial logistic regression. As such, two models were created for each of the four offence types (assault, domestic violence, burglary, and arson), each represented using the mean classification (multinomial logistic regression) and the natural

classification (binary logistic regression). The regression modelling was carried out in R, using the `mlogit` function (from the package of the same name) for the multinomial logistic models, and the `glm` function for the binary logistic models. The near to mean category (1) was used as the reference category for the multinomial models, and the less than natural change category (0) was used as the reference category for the binomial models. Specific variables, hypothesised to be related to greater or less than normal post-earthquake rate changes were added to each model in a step-wise process, and evaluated based on statistical significance and improvement to the Akaike Information Criterion (AIC) value. Models were constructed iteratively, using multiple combinations of the constructed independent variables. Where alternate variables were available (representing the same concept), the variable was chosen based on increases in model quality, and/or the presence of a statistically-significant relationship.

Following the exhaustion of all available combinations of relevant independent variables for each of the eight models, the residuals of each model were extracted to test for the presence of spatial autocorrelation, a limitation of logistic regression (Lamichhane et al., 2013). Joining these residuals back to the original CAU boundaries, the presence of spatial autocorrelation was tested using Global Moran's I in ArcGIS. The spatial relationships for the Moran's I test was defined as *Contiguity Edges and Corners* (also known as a 'Queen's Contiguity'), meaning that only a first order spatial influence was considered. Using the obtained Moran's I and p-values, each model was assessed for the presence of spatial autocorrelation.

Chapter 5 Results

The following results are separated into three sections. The first section provides a descriptive analysis of how crime varied following the Canterbury Earthquakes (both in the short- and moderate-term). In the second section the findings of the spatio-temporal analysis are detailed. Last, the results of the regression analysis are provided which investigate the nature of the relationship between crime rate changes and various neighbourhood level variables.

5.1 Descriptive statistics

Overall descriptive statistics for offending in the pre- and post-disaster periods are shown in Table 11. Average crime rates across the pre- and post-disaster periods show that in general, three of the four offence types (assault, burglary, and arson) decreased between pre-disaster to post-disaster, whilst domestic violence increased. Comparing the average annual offence counts in the pre- and post-disaster periods, average annual counts of assault fell 12.61 percent, burglary fell 17.86 percent, and arson fell 60.42 percent. Conversely, the average annual counts of domestic violence increased by 45.52 percent between the pre- and post-disaster periods. Aside from slight deviations in percentage change, these same trends were present in both offence counts and crime rates, indicating that these trends were independent of post-earthquake population changes in Christchurch.

Plotting monthly crime rates across the entire study period illustrated a number of trends and fluctuations in offending before, during, and after the Canterbury Earthquakes (see Figure 14). The overall changes in offending (decreased assault, burglary, and arson, and increased domestic violence) are clear, though substantial month-to-month fluctuations are apparent.

Table 11 Crime average annual rates (per 10,000 population) and counts for Christchurch July 2008 to June 2013

		Counts and Rates		% Change
		Pre-Disaster	Post-Disaster	Pre-Disaster to Post-Disaster
Assault				
	<i>Annual Average Count</i>	3151.5	2754	-12.61%
	<i>Annual Average Rate</i>	86.65	79.47	-8.28%
Domestic Violence				
	<i>Annual Average Count</i>	223	324.5	45.52%
	<i>Annual Average Rate</i>	6.13	9.36	52.73%
Burglary				
	<i>Annual Average Count</i>	5985.5	4916.5	-17.86%
	<i>Annual Average Rate</i>	164.56	141.87	-13.79%
Arson				
	<i>Annual Average Count</i>	851.5	337	-60.42%
	<i>Annual Average Rate</i>	23.41	9.72	-58.46%

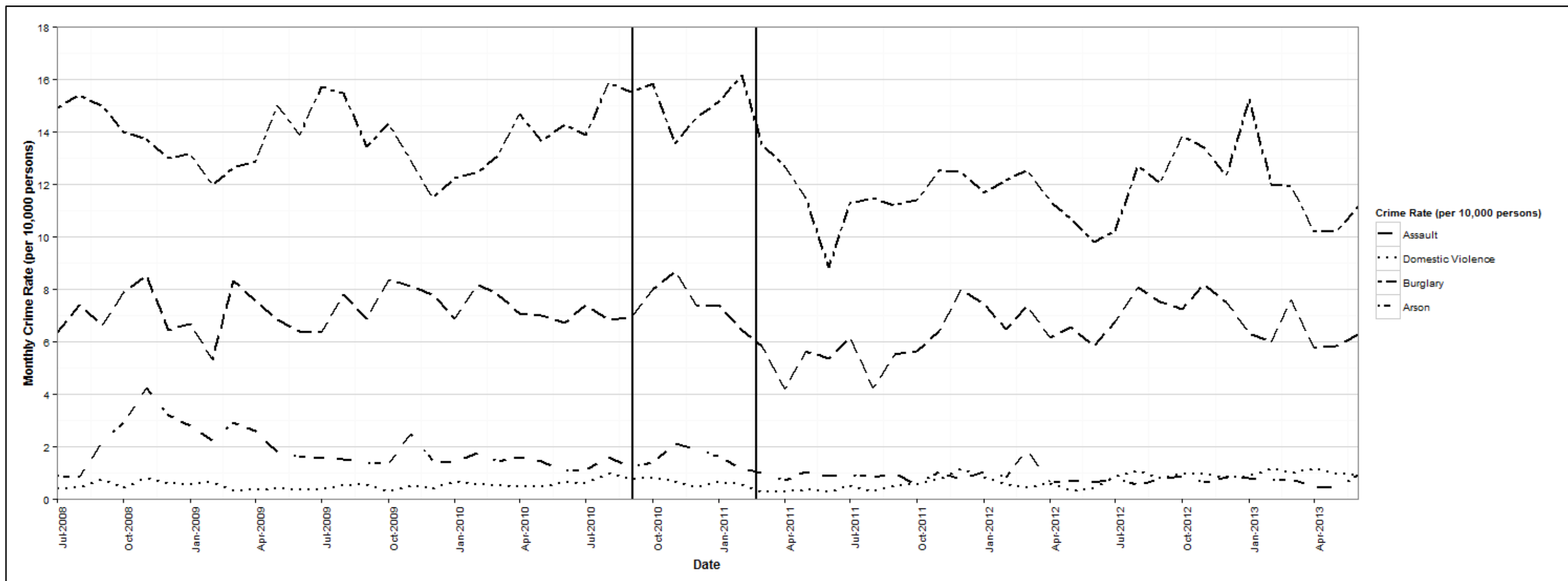


Figure 14 Monthly crime rates (per 10,000 persons) for Christchurch between July 2008 and June 2013, with the Darfield (September 2010) and Christchurch Earthquakes (February 2011) marked

Prior to the onset of the Canterbury Earthquakes crime rates appear relatively stable in trend, except for arson, which appears to already trend downwards before September 2010. Though slight decreases were observed in domestic violence, burglary, and arson, and a marginal increase in assault were observed for the month of the Darfield Earthquake (September 2010), these changes were insubstantial and unremarkable compared to prior fluctuations. Following the Darfield event all offence rates rose, though again the magnitude of these changes was negligible. Interestingly, November 2010 saw the peak monthly assault rate for the observation period, but also saw a substantial drop in burglary rate. Crime rates for the month of the Christchurch Earthquake (February 2011) showed a general decrease, but notably the burglary rate increased, peaking for the observation period.

Following the Christchurch Earthquake, variation in crime rates became far more distinct, most notably a sharp decrease in burglary rates (through to its lowest point in June 2011). In the months immediately after the Christchurch Earthquake a notable lull was observed in all observed offences. The duration of this lull varied greatly, lasting around four months for domestic violence, nine months for assault, nineteen months for burglary, with arson never again exceeding the average rate of the pre-disaster period. Assault and burglary rates recovered following the post-Christchurch Earthquake lull, though remained (on average) lower than the pre-disaster period. Domestic violence gradually increased for the remainder of observation, with peaks in February and April 2013. Notably, domestic violence rates consistently exceeded arson rates in and after July 2012, where previously such occurrences were extremely rare. Overall trends in arson rates were relatively unremarkable, save for a distinct minor peak in March 2012.

Figure 15 (Darfield Earthquake) and Figure 16 (Christchurch Earthquake) shows the short-term temporal variations in offending for the 28 days either side of the two primary events of the Canterbury Earthquakes. Variations in offending around the Darfield Earthquake were not incongruent with normal day-to-day fluctuations. Though the burglary rate the day after the Darfield Earthquake (5th September 2010) was the highest for the observation window, it was not substantially greater than other observed burglary rates. Perhaps the most notable observation over this period was a slight lull in assault activity, before spiking on the 18th and 24th of September. Arson was heightened on the day of the Darfield Earthquake relative to the four days prior, but was well within the variances in the period.

Daily crime rates around the Christchurch Earthquake displayed far more distinct trends compared to the variation in daily crime rates experienced around the Darfield Earthquake. The day of the Christchurch Earthquake (22nd February 2011) burglary rates peaked considerably (twice the day prior) and remained elevated for nine days. Assault rates experienced a short dip that began on the 21st and continued for another three days, with the 22nd and 23rd of February being the joint lowest (along with 14th of March) for assault rates in the observation window. The 22nd of February was the beginning of a five day period with no domestic violence offences being recorded, though this was not uncommon in the observation window.

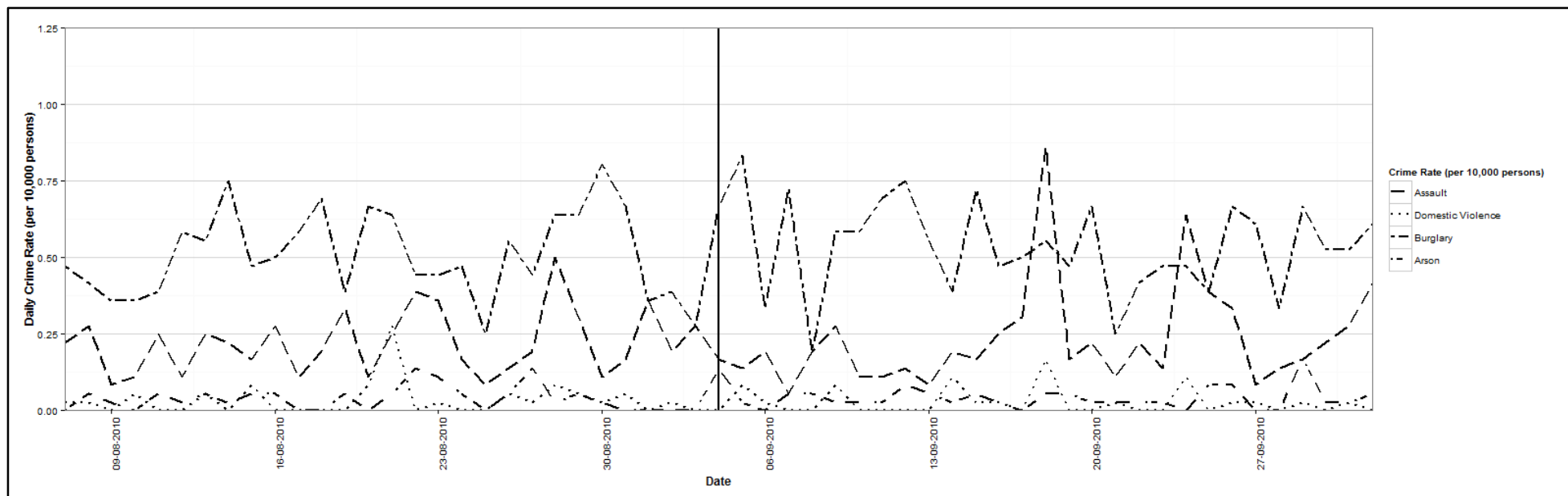


Figure 15 Daily crime rates (per 10,000 persons) over 57 days around the Darfield Earthquake

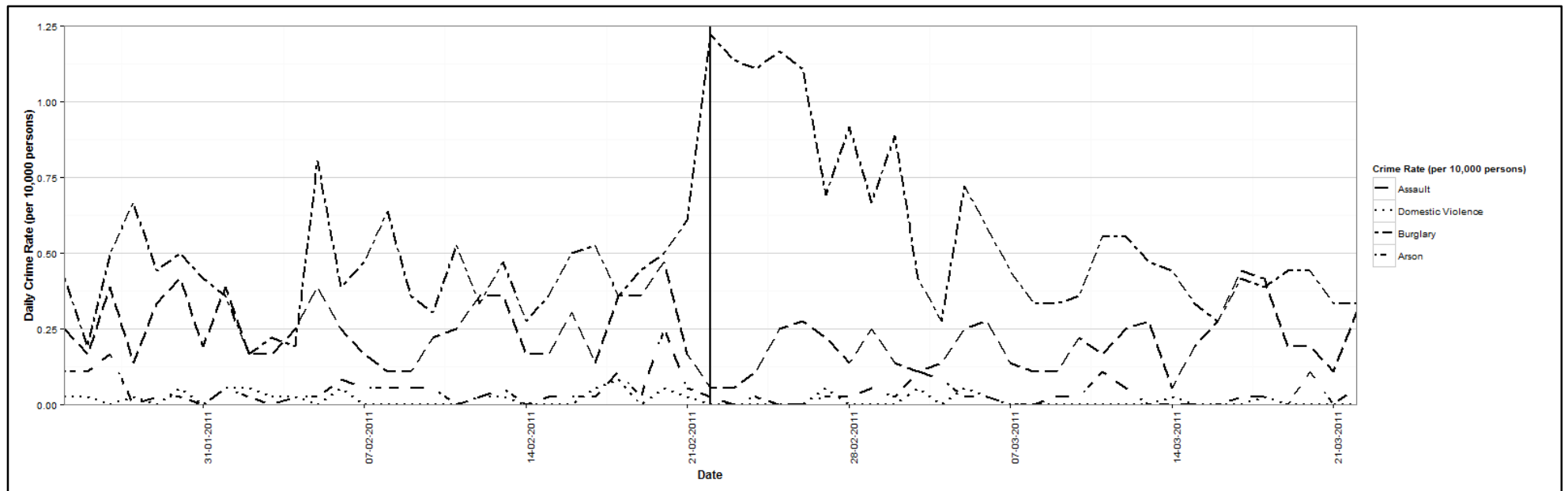


Figure 16 Daily crime rates (per 10,000 persons) over 57 days around the Christchurch Earthquake

Temporal profiles were constructed for each offence type, characterising each offence by the day of the week and time of day of occurrence. Radar plots were constructed for each offence, separating the temporal characteristics into the pre-disaster, disaster, and post-disaster periods to realise any differences in the temporal characteristics of offending following the Canterbury Earthquakes (see LeBeau, 2002).

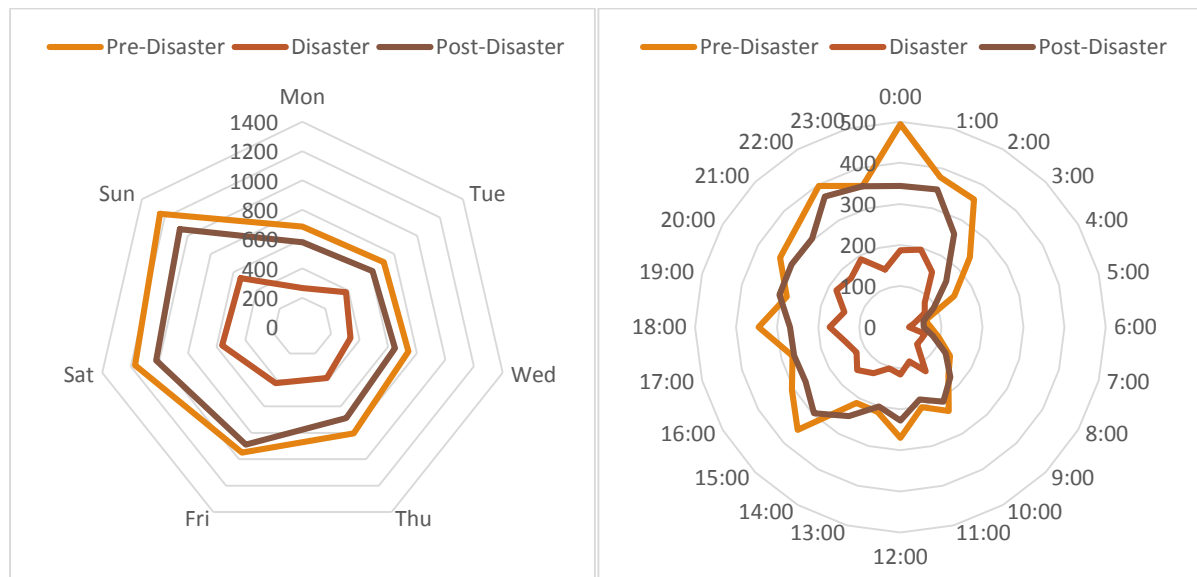


Figure 17 Daily and hourly temporal profiles of assault across the three earthquake periods

Across all three periods assault is concentrated in times of usual social activity with most assaults taking place on the weekend and Friday, and between the late afternoon, evening, and the early hours of the morning (see Figure 17). Overall the temporal profile of assault remains consistent across the three study periods.

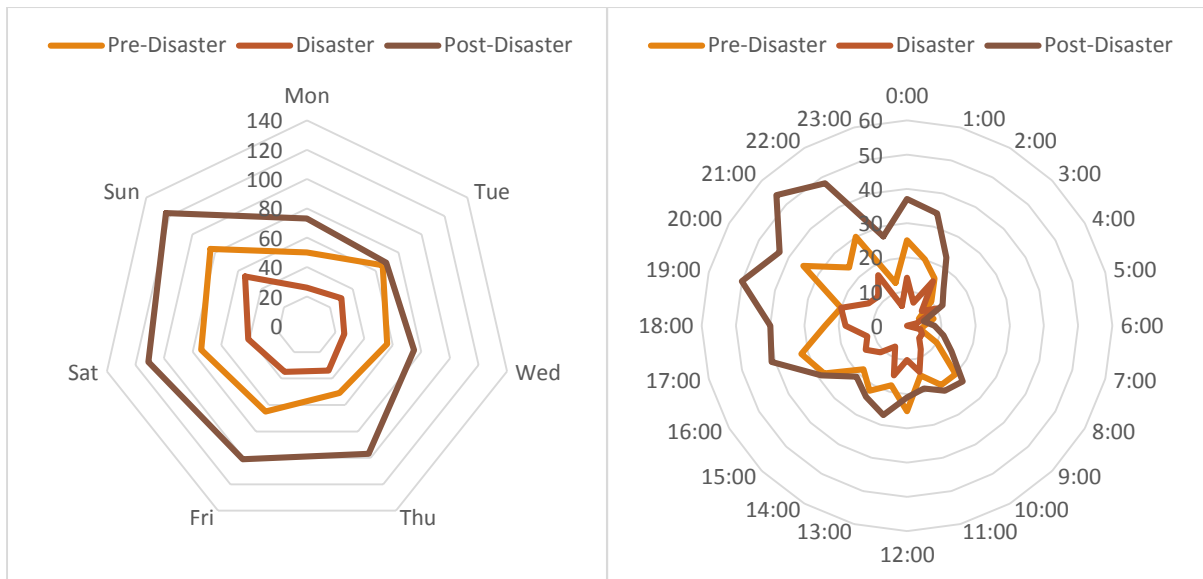


Figure 18 Daily and hourly temporal profiles of domestic violence across the three earthquake periods

Domestic violence offences were most prevalent between Friday and Sunday for all three periods (see Figure 18). The timing of reported domestic violence offences was similar for all three periods, and was notably lowest between 3:00 and 8:00 AM, whilst most offending occurred in the evening, between 5:00 and 11:00 PM. Again, no major differences were found in the profiles across the three earthquake periods.

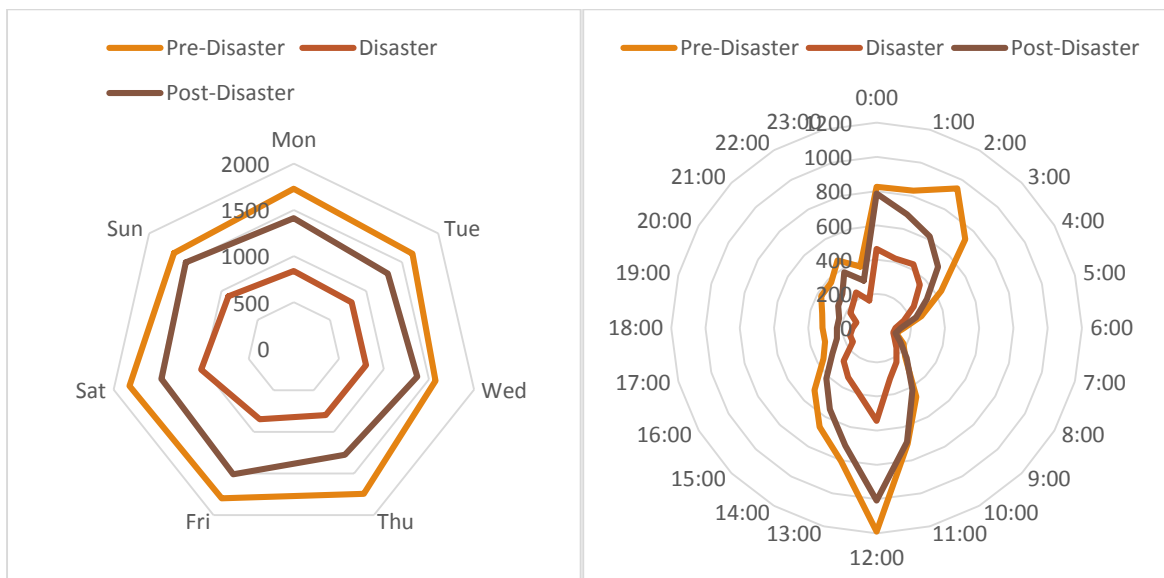


Figure 19 Daily and hourly temporal profiles of burglary across the three earthquake periods

Burglary display a relatively even distribution over the days of the week, peaking on Saturdays in both the pre-disaster and disaster periods (see Figure 19). The time of day of burglary

offending is bimodal, with two exaggerated peaks (focused on 2:00 AM and 12:00 PM) present in all three periods. Burglary becomes heightened from midnight through the early hours of the morning. The other peak in offending occurs around midday. This likely represents a reporting artefact, relating to NZ Police reporting procedures, which in the absence of an exact time of offence, the time recorded is the midpoint between the earliest and latest time of offence. In the case of burglary, this spike is likely representative of offences carried out during the working day, which are discovered upon returning to one's place of residence, the midpoint being between 12:00 and 1:00 PM. As such this spike in activity is likely distributed more evenly throughout working hours, though it still represents a significant number of offences.

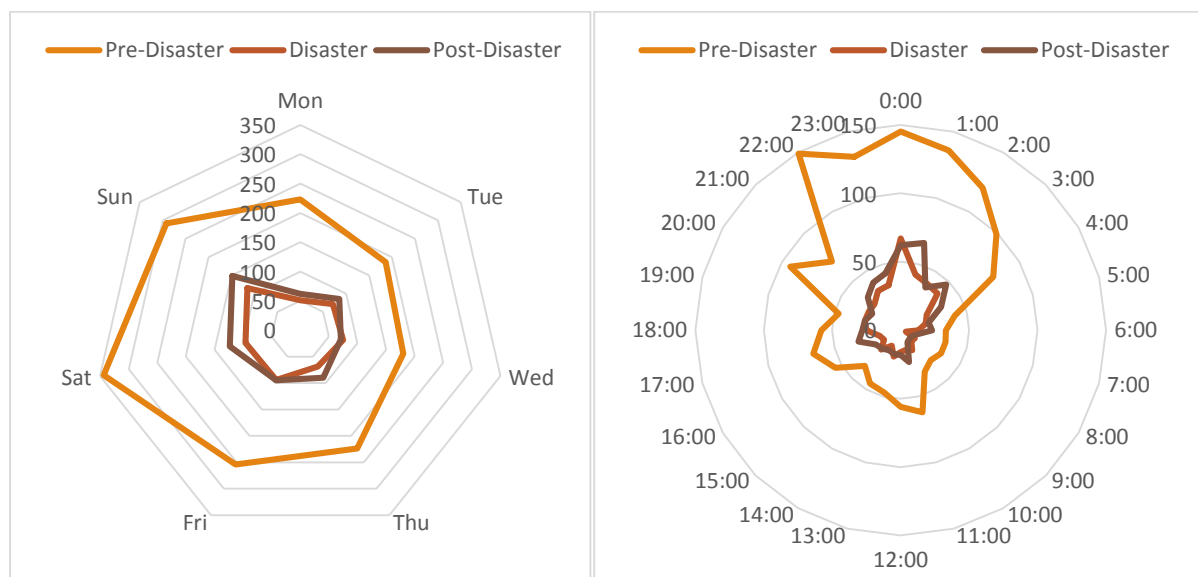


Figure 20 Daily and hourly temporal profiles of arson across the three earthquake periods

Arson offences were most prolific on Saturdays and Sundays, with Sunday being the day of highest offending in the disaster and post-disaster periods, and Saturday for the pre-disaster period (see Figure 20). Arson in the disaster and post-disaster periods display very similar temporal profiles, even in the number of offences, notable as the disaster period is half the duration of the post-disaster period. Arson in all periods is more prevalent in the late evening and early morning, particularly evident in the pre-disaster period.

5.2 Spatio-temporal analysis

The following maps illustrate the results of the spatio-temporal analysis of changing spatial crime distributions in Christchurch following the Canterbury Earthquakes. For each offence a KDE layer was created to represent the spatial distribution of offending in the pre- and post-disaster periods, whilst the DKDE layer illustrates the difference between the two. The KDE maps provide an indicative representation of *offences per square kilometre*, that is to say that areas of darker red represent higher spatial concentrations (hotspots) of that offence type. The DKDE maps represent the difference values between the pre- and post-disaster periods, showing the change in offence density. That is to say that areas of darker red indicate high increases in offence density, areas of dark blue indicate large decreases in offence density, and lighter areas show minimal differences in offence density. As such, the DKDE maps show the differences between crime distributions, not the concentration of offending.

The overall spatial distribution of assault in Christchurch between the pre-disaster (Figure 21A) and the post-disaster (Figure 21B) appears somewhat similar, despite the substantial reduction in the highest observed density value. Most notably the distribution of assault concentrates in Christchurch's CBD and in the suburbs immediately to the east of the CBD. The post-disaster map has a notable absence of offending in the CBD area. The DKDE layer for assault (Figure 21C) highlights the differences between the distributions, most notably an enormous decrease in assault in the CBD. There is also a reduction in assault in the suburbs to the east of the CBD, and very slightly in the Residential Red Zone. Increases in assault were evident in a number of key areas to the north and west of the CBD, including Riccarton, Upper Riccarton, and Hornby.

The spatial distribution of domestic violence in the pre-disaster and post-disaster periods was relatively similar (see Figures 22A and 22B), though in the post-disaster map there is a notable increase in domestic violence in some of the far-western suburbs, and decreases in domestic violence in Christchurch's CBD and in the Residential Red Zone. These observations are highlighted in Figure 22C, along with notable areas of increased domestic violence throughout the inner suburbs of Christchurch, not immediately apparent in the pre- and post-disaster maps.

Again, the pre-disaster and post-disaster spatial distributions of burglary appear very similar (see Figures 23A and 23B), except for an apparent decrease in burglary just south of the CBD, and an increase in burglary just to the north west of the central city. The DKDE layer for burglary exhibits a very distinct pattern, with a very apparent increase in burglary densities in the Residential Red Zone area, and decreases throughout the rest of the city (see Figure 23C). A more minor increase in burglary is also present in a small area to the west, near the city boundary of Christchurch.

The arson KDE layers for the pre-disaster and post-disaster periods exhibit the most dispersed distribution of any of the observed offences (see Figures 24A and 24B). In both maps, arson concentrates along a central area that includes the CBD and the suburbs to the south of the city. Notably there appears to be a much lower density of arson offences in the suburbs to the north of this band. Examining the DKDE map (Figure 24C), the same central band of arson highlighted previously, shows a decrease in offending, illustrating a broad decrease in arson in these hotspots. Distinct from the other offences, the DKDE for arson shows no substantially-large areas of increased offending.

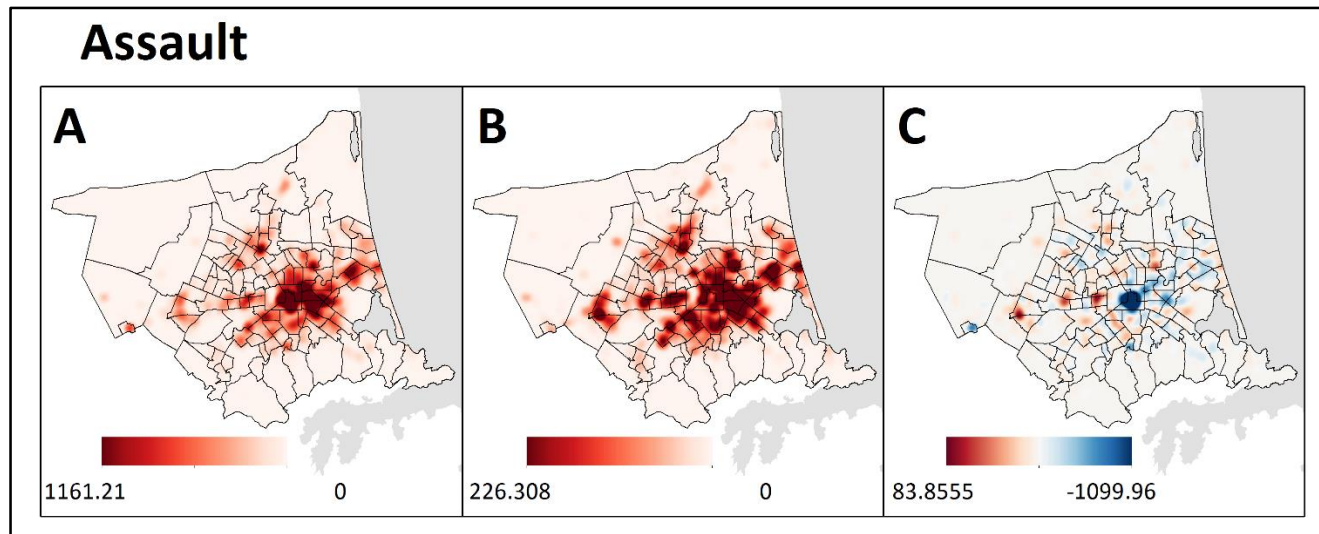


Figure 21 Assault Kernel Density Analysis A) pre-disaster (per square kilometre), B) post-disaster (per square kilometre), and C) Dual Kernel Density layer

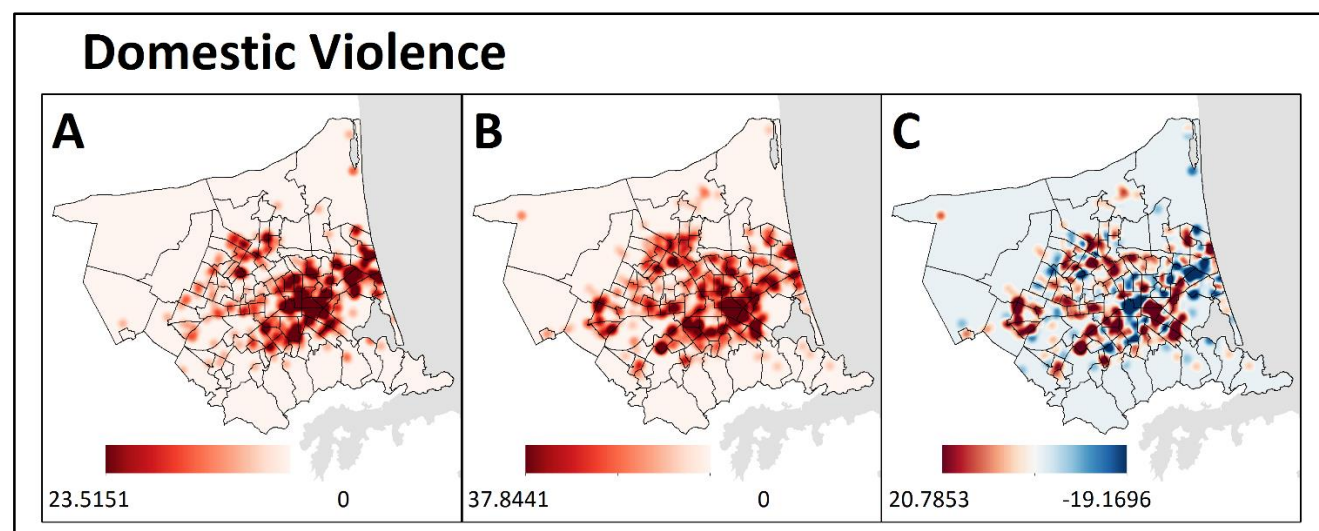


Figure 22 Domestic violence Kernel Density Analysis A) pre-disaster (per square kilometre), B) post-disaster (per square kilometre), and C) Dual Kernel Density layer

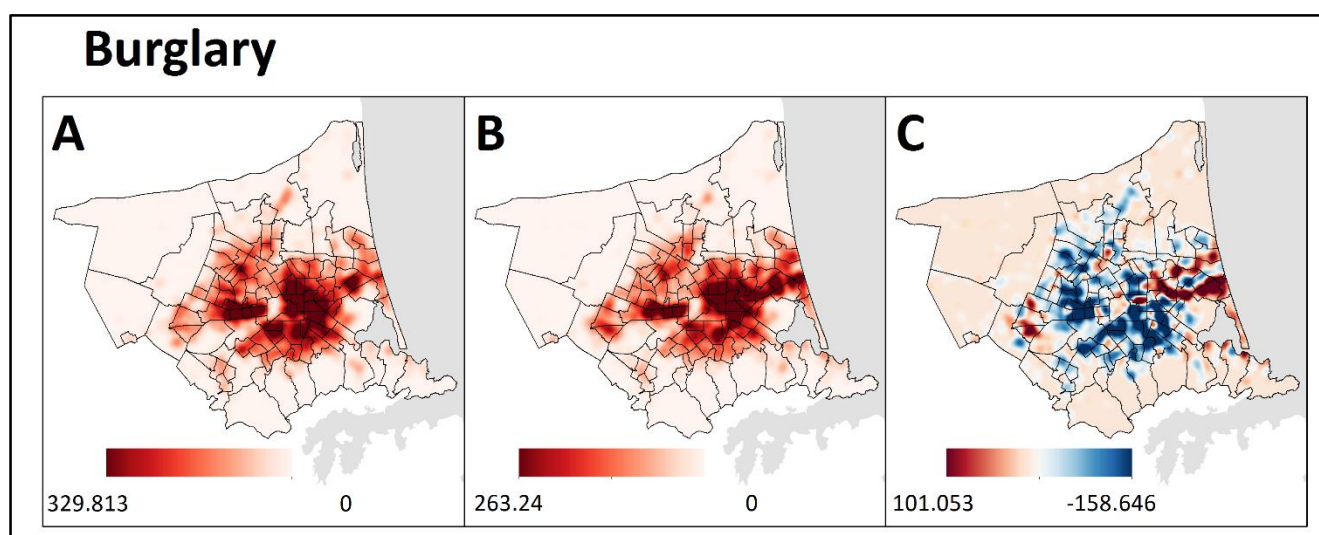


Figure 23 Burglary Kernel Density Analysis A) pre-disaster (per square kilometre), B) post-disaster (per square kilometre), and C) Dual Kernel Density layer

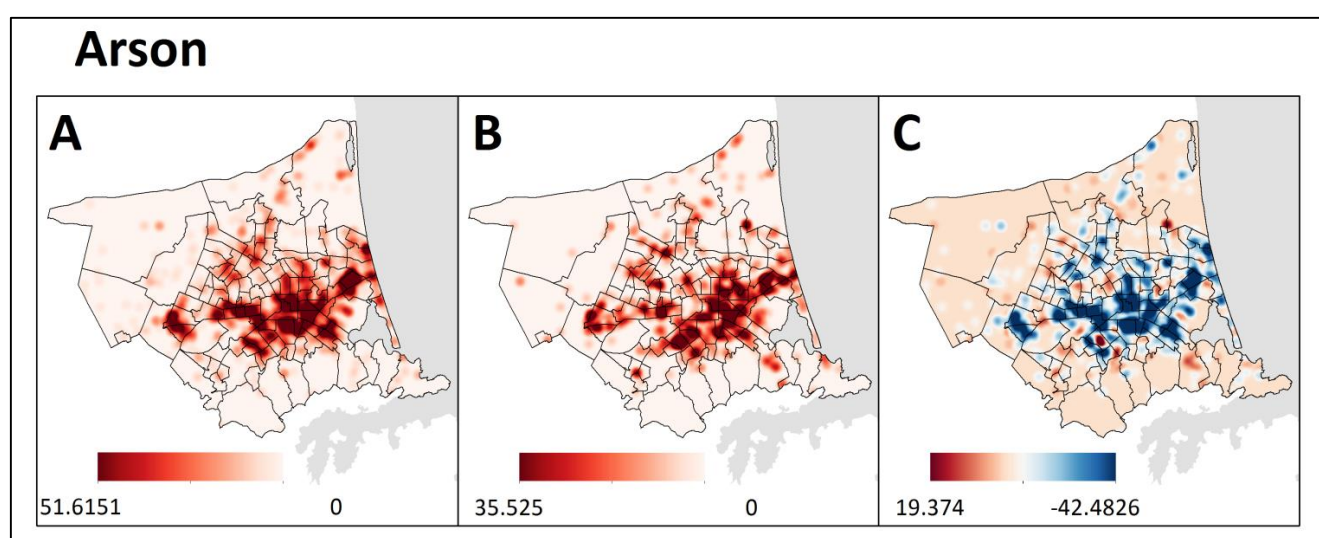


Figure 24 Arson Kernel Density Analysis A) pre-disaster (per square kilometre), B) post-disaster (per square kilometre), and C) Dual Kernel Density layer

5.3 Regression

Eight logistic regression models were constructed using the dependent variables outlined earlier, to examine any present relationships between changes in crime rate and a range of independent variables based on the ideas of Social Disorganisation, Routine Activity, and Strain Theory.

Descriptive Statistics

Descriptive statistics for the four offence-specific crime rates, across all 116 of Christchurch's CAUs and across the three study periods are provided in Table 12. Observed crime rates varied considerably over Christchurch, as evidenced by the substantial disparities between maximum and minimum crime rates, and the standard deviations observed. Notably, nil (average) annual crime rates were observed over a number of CAUs across all crime types and time periods, with the exception of burglary, indicating that in some areas of Christchurch there was a complete absence of reported offences. This observation was most pertinent to domestic violence, where large numbers of CAUs across the pre-disaster (22), disaster (30), and post-disaster (13) periods had no reported offences. Conversely, the Cathedral Square CAU (representative of Christchurch's CBD) displayed the highest crime rates, having the maximum rates for all offence types and periods, except for the pre-disaster and disaster figures for arson. This trend is less noticeable when examining raw counts, showing that the CBD's low resident population is a factor here.

Table 12 Descriptive statistics for crime rates (per 10,000 persons) for the CAUs across the study period

	Maximum	Mean	Median	Minimum	Standard Deviation
Assault					
<i>Pre-Disaster</i>	4126.09	111.89	47.94	4.46	382.98
<i>Post Disaster</i>	1121.21	88.32	58.55	4.95	118.60
Domestic Violence					
<i>Pre-Disaster</i>	86.96	6.38	4.02	0.00	9.40
<i>Post Disaster</i>	75.76	9.82	7.59	0.00	10.11
Burglary					
<i>Pre-Disaster</i>	1321.74	181.10	144.22	41.18	149.60
<i>Post Disaster</i>	1143.94	156.08	120.81	23.42	136.37

Arson					
<i>Pre-Disaster</i>	250.00	28.88	19.96	0.00	37.43
<i>Post Disaster</i>	98.48	11.44	8.54	0.00	12.96

Table 13 Descriptive statistics for crime rate change between the pre- and post-disaster periods

	Maximum	Mean	Median	Minimum	Standard Deviation
Crime Rate Change					
<i>Assault</i>	95.34	-23.57	2.91	-3004.87	281.18
<i>Domestic Violence</i>	41.67	3.44	2.60	-22.73	7.37
<i>Burglary</i>	288.43	-25.02	-31.71	-331.17	82.56
<i>Arson</i>	15.57	-17.43	-10.12	-205.36	28.53

Descriptive statistics for the change in crime rates across Christchurch's CAUs between the pre- and post-disaster periods are presented in Table 13. As shown by the mean values, localised crime rate change generally decreased (with the notable exception of domestic violence), though substantial variability was evident. The average change in burglary rate (-25.02) was larger in magnitude than for assault (-23.57), however the variation in crime rate change for assault was much greater, as evidenced by the substantially larger standard deviation. Examining the CAUs experiencing the maximum and minimum crime rate changes, no single CAU was ranked the highest or lowest more than once. The most distinct changes observed were the minimum changes in assault and arson rates, with the Cathedral Square CAU displaying a decrease in assault rate of 3004.88 offences per 10,000 persons, and the Riccarton South CAU where the arson rate fell by 205.36 offences per 10,000 persons. Examining the ten top- and bottom-ranked CAUs for crime rate change, Cathedral Square and Prestons were ranked among the bottom ten CAUs across all four offences, whilst the Middleton and Richmond CAUs were ranked in the bottom ten for three offence types. Conversely, among the ten top-ranked CAUs for crime rate change, no area featured in more than two offences. This suggests that whilst there may be some association between the areas experiencing the lowest of crime rate changes (between crime types), the areas experiencing the highest crime rate changes may have been more broadly distributed. Examining inter-offence relationships further, a correlation analysis (see Table 14) identified relatively weak, but statistically-significant relationships occurring between change in assault rate, and

changes in domestic violence (+) and burglary (+), and change in arson rate, and changes in domestic violence (-) and burglary (+). These correlations demonstrate a general positive association between the four crime rate change variables, with the sole negative association between change in arson and domestic violence indicating a general dissimilarity in areas that experienced an increase or decrease in both variables.

Table 14 Correlational analysis of crime rate change

	Assault rate change	Domestic Violence rate change	Burglary rate change	Arson rate change
Assault rate change	1			
Domestic Violence rate change	.213*	1		
Burglary rate change	.217*	.042	1	
Arson rate change	.168	-.369**	.304**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Examining the classified dependent variables, the distribution of values per CAU for the mean classification dependent variable vary considerably (see Table 15). Three variables (domestic violence, burglary, and arson) showed substantially greater numbers of CAUs in either the greater than, or less than mean categories, and comparatively few in the similar to mean category. This indicates that crime rates in CAUs post-earthquake were frequently different to the mean change across the city. Of these three variables, domestic violence and burglary show the greatest similarity, with the greatest number of CAUs being categorised as less than mean change. The assault variable differs substantially as 50 percent of CAUs are in the similar to mean category, a proportion far greater than the other three offences suggesting that changes in assault rates were largely in-line with the average across the city. . In addition, the assault variable has the lowest representation in a single category, with only 5.17 percent of CAUs in the less than mean change category. The natural classification (see Table 16) produced more evenly distributed values, with both assault and arson variables being comparatively even. The domestic violence and burglary variables both favoured one classification, greater than natural change and less than natural change, respectively. The

domestic violence variable shows the greatest imbalance in the natural classification with a 68.97/31.03 percent distribution between the two categories.

Table 15 Mean classification by CAU (multinomial) totals – greater than, near to, or less than mean

	Less than mean change (0)	Near to mean change (1)	Greater than mean change (2)
Assault	6 (5.17 %)	58 (50 %)	52 (44.83 %)
Domestic Violence	59 (50.86 %)	9 (7.76 %)	48 (41.38 %)
Burglary	55 (47.41 %)	20 (17.24 %)	41 (35.34 %)
Arson	33 (28.45 %)	10 (8.62 %)	73 (62.93 %)

Table 16 Natural classification by CAU (binary) totals – greater than, or less than natural change

	Less than natural change (0)	Greater than natural change (1)
Assault	53 (45.69 %)	63 (54.31 %)
Domestic Violence	36 (31.03 %)	80 (68.97 %)
Burglary	73 (62.93 %)	43 (37.07 %)
Arson	62 (53.45 %)	54 (46.55 %)

The two sets of dependent variables were mapped to analyse their spatial distribution. Figure 25 shows the distribution of the mean classification (multinomial) dependent variables. From a preliminary assessment of the distributions, the imbalance between the three categories is immediately apparent. Notably the CBD area is in the less than mean change category for all four offences. For assault, the substantial presence of the near to mean category is clearly evident, and there is a large cluster in a central area to the south of the CBD. Inversely, CAUs experiencing a greater than average crime rate change are more prominent to the north, with a distinct cluster in the eastern suburbs, where the Residential Red Zone is also located. The domestic violence map shows two areas of clear clustering of the greater than mean category directly to the east and west of the CBD. Notably the southern-most CAUs in the city were all classified in the less than mean change in crime rate. The distribution of burglary contains a distinct east west divide, with a concentration of CAUs with crime rate change greater than mean to the east, including a concentrated block in the Residential Red Zone. The arson map is perhaps the most striking of the four offences, with three areas of distinct clusters of the

greater than mean change in crime rate category: two to the south of the CBD, and the largest in a central block above the CBD.

Figure 26 shows the spatial distribution of the natural classification (binomial) dependent variables. Again the CBD CAU is prominent in the lower than natural change category in all four offences. This is understandable given the destruction and damage sustained to this area of the city. The distribution of the assault variable is rather scattered, though notably all areas adjacent to the east coastline are all classed as experiencing greater than natural change in crime rate. Moreover, a number of these areas also coincide with the Residential Red Zone. The domestic violence map is dominated by CAUs experiencing a greater than natural change in crime rate, with a distinct concentration in the north and northeast part of the city. Similar to assault, no clear spatial pattern is apparent. Like domestic violence, the distribution of burglary is largely masked by the imbalance in classes. The greater than natural change CAUs display a clear concentration through the centre of the city, with nearly uniform areas of the less than mean change class to the north and south. The central band notably concentrates in the Residential Red Zone and a group of the western suburbs. The arson variable is also somewhat indistinct, though the greater than natural CAUs tend to favour the southern parts of the city.

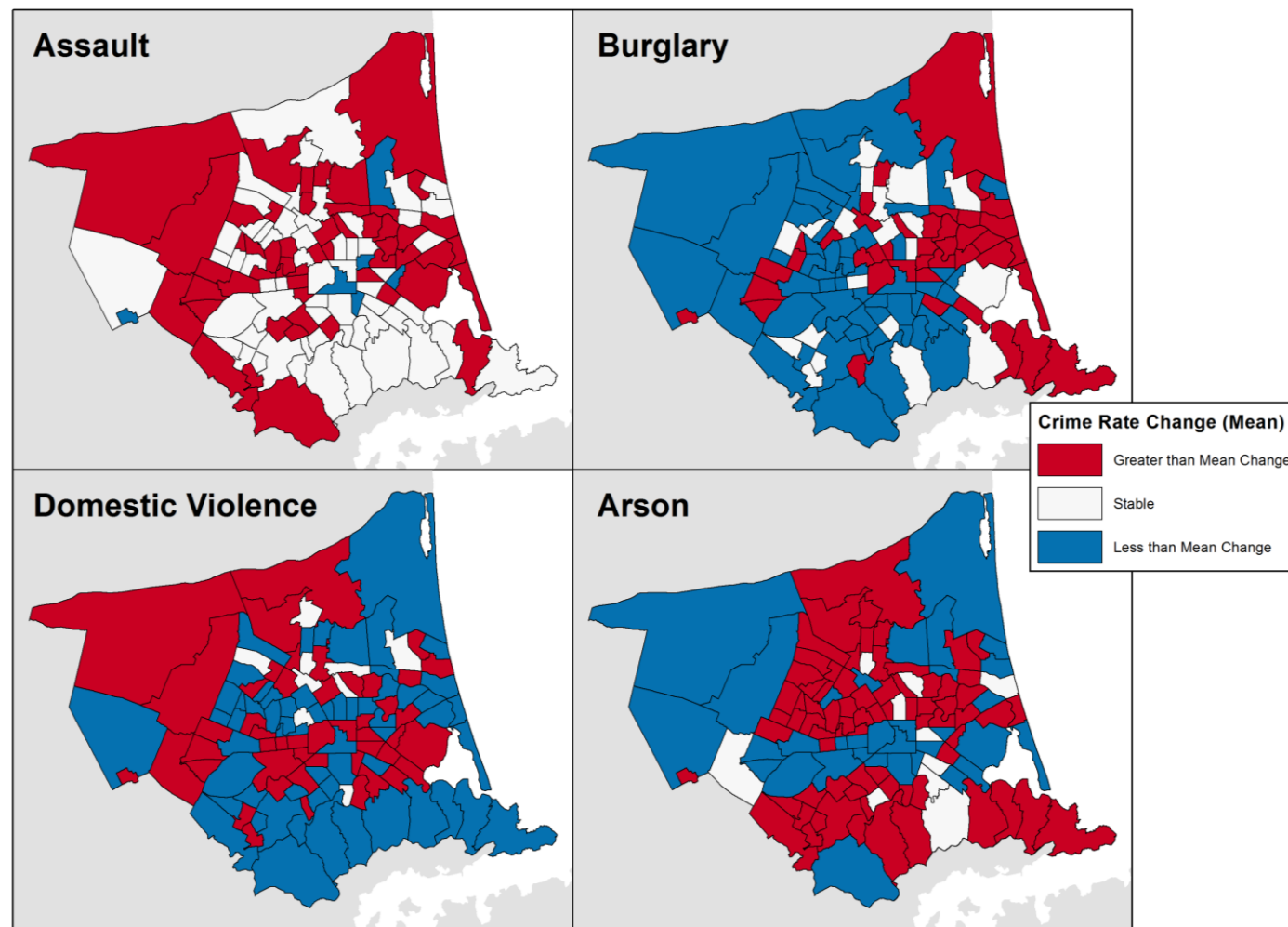


Figure 25 Spatial distribution of mean classification

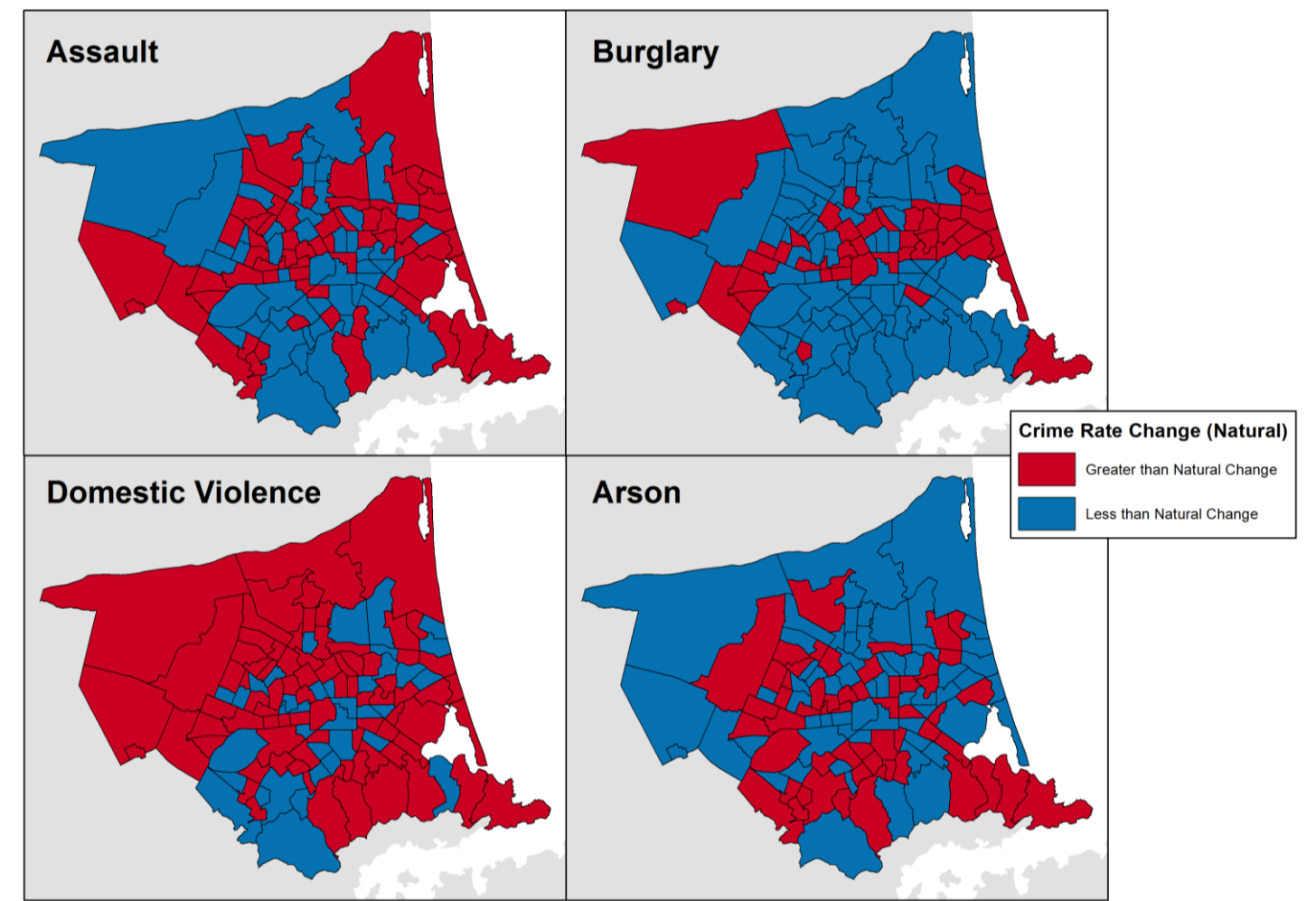


Figure 26 Spatial distribution of natural classification

Multinomial logistic regression (mean classification)

Multinomial logistic regression was used to examine the relationships between various neighbourhood level variables, and the likelihood of areas in Christchurch experiencing a greater (2), similar (1) or lower (0) than mean change in crime rate after the Canterbury Earthquakes. Table 17 summarises the results of the multinomial logistic regression models. Model performance, based on the AIC values, indicated that the arson (192.514) model performed the best, followed by assault (202.795), domestic violence (207.423), and then burglary (225.401).

Statistically-significant positive relationships were identified between a lower than average change in assault rate, and deprivation (+0.061) and alcohol outlet density (+0.193). This indicated that in more deprived areas and where alcohol was more readily accessible, the change in assault rate after the Canterbury Earthquakes was more likely to be lower than the average for Christchurch. A statistically-significant negative association was identified between ethnic heterogeneity (-35.489) and a lower than average change in assault rate. This indicated that in less ethnically heterogeneous CAUs, where minority populations were smaller, the change in assault rate was more likely to be less than average. The relationships with deprivation and ethnic heterogeneity were found to be more statistically-significant (0.003 and 0.008, respectively), than the relationship with alcohol outlet density (0.039) indicating a stronger relationship with the former variables. Variables representing the participation in unpaid activities, post-earthquake dwelling loss, post-earthquake increases of immigrants, and socioeconomic inequality were all found to be non-significant.

In terms of domestic violence, the multinomial logistic regression model identified a sole significant relationship. Specifically, a positive association was found with deprivation (+0.026) indicating that more highly deprived areas were more likely to experience a greater than average change in domestic violence post-earthquake. Variables including participation in unpaid activities, post-disaster dwelling change, alcohol accessibility, and ethnic and socioeconomic heterogeneity were all found to be non-significant.

The multinomial logistic regression model for burglary identified two statistically-significant relationships with deprivation (+0.021) and change in dwelling number (-6.156) variables. These associations indicate that more deprived areas and those experiencing a greater

reduction in the number of dwellings and homes were more likely to experience a greater than average change in post-disaster burglary. Though the relationship with deprivation was weakly significant (0.032), the relationship with dwelling change was highly significant (0.005). Variables measuring increases in immigrant populations, ethnic and socioeconomic heterogeneity, and participation in voluntary activities were all found to be non-significant.

The multinomial logistic regression model for arson also identified a single statistically-significant relationship with deprivation (-0.023). This association indicates that more affluent areas were more likely to experience a greater than average change in arson post-quake. This relationship was only weakly significant (at 0.037). Factors of participation in unpaid activities, change in dwelling number, ethnic and socioeconomic heterogeneity, and increases/decreases in immigrant population were all found non-significant.

Table 17 Results of multinomial logistic regression models

Variables ¹ Base Category 1		Assault				Domestic Violence				Burglary				Arson			
		Estimate	Std Error	t-value	Pr (> t)	Estimate	Std Error	t-value	Pr (> t)	Estimate	Std Error	t-value	Pr (> t)	Estimate	Std Error	t-value	Pr (> t)
NZDep	0	0.061	0.021	2.988	0.003**	0.015	0.012	1.216	0.224	0.013	0.009	1.496	0.135	-0.007	0.012	-0.593	0.553
	2	0.005	0.006	0.759	0.448	0.026	0.012	2.116	0.034*	0.021	0.010	2.150	0.032*	-0.023	0.011	-2.081	0.037*
Ethnic heterogeneity ²	0	-35.489	13.318	-2.665	0.008**	-	-	-	-	-2.274	4.345	-0.524	0.601	4.839	8.538	0.567	0.571
	2	-5.239	4.307	-1.217	0.224	-	-	-	-	-6.995	5.439	-1.286	0.198	8.398	8.299	1.012	0.312
% Unpaid service	0	-20.144	16.969	-1.187	0.235	7.052	10.373	0.680	0.497	-	-	-	-	-17.330	11.379	-1.523	0.128
	2	-5.358	5.881	-0.911	0.362	2.477	10.734	0.231	0.817	-	-	-	-	-4.166	10.780	-0.386	0.699
% Dwelling change	0	4.693	2.531	1.854	0.064	-0.909	1.386	-0.656	0.512	-0.112	1.094	-0.103	0.918	1.915	1.855	1.032	0.302
	2	-0.558	0.996	-0.561	0.575	0.062	1.395	0.044	0.965	-6.156	2.202	-2.796	0.005**	0.281	1.790	0.157	0.875
% Change in foreign born	0	-24.755	17.508	-1.414	0.157	-	-	-	-	3.169	10.227	0.310	0.757	-24.851	16.491	-1.507	0.132
	2	-2.031	7.811	-0.260	0.795	-	-	-	-	4.347	11.979	0.363	0.717	-24.991	16.439	-1.520	0.128
Alcohol outlet density ³	0	0.193	0.093	2.065	0.039*	-0.020	0.084	-0.240	0.811	-	-	-	-	-	-	-	-
	2	0.061	0.049	1.235	0.217	0.005	0.082	0.060	0.952	-	-	-	-	-	-	-	-
AIC		202.795				207.423				225.401				192.514			
* Significant to the 0.05 level																	
** Significant to the 0.01 level																	
¹ Variable choice was based on the theoretical framework and the presence of significant relationships																	
² Measure of percentage of minority population																	
³ Measure of number of on- and off-license alcohol outlets per square kilometre																	

Binary logistic regression (natural classification)

Binomial logistic regression was used to examine the relationships between neighbourhood level variables, and the likelihood of areas in Christchurch experiencing crime rate change exceeding (1) or not exceeding (0) that observed prior to the Canterbury Earthquakes (representative of natural fluctuations in offending). Again categories are not innately increases or decreases in crime, rather whether crime rate change was above or below the natural crime rate change observed prior to the Canterbury Earthquakes.

Based on the AIC values of the models, burglary performed the best (141.84), followed by assault (149.89), domestic violence (156.34), and arson (166.58) (see Table 18). The comparison of the null and residual deviance values also suggested that burglary performed the best, followed by assault, arson, and domestic violence. Overall both the arson and domestic violence models performed poorly, providing little explanatory or predictive value.

The binary logistic model for assault highlighted a number of statistically-significant relationships. A positive association was found with ethnic heterogeneity (+0.002), whilst negative associations were found with deprivation (-0.030), participation in unpaid activities (-16.721), and change in occupied dwellings (-3.951). These associations indicate that in more affluent CAUs, with greater ethnic heterogeneity, lower levels of participation in unpaid activities, and where the number of occupied dwellings decreased, the change in assault rate was more likely to be greater than that experienced prior to the Canterbury Earthquakes. The relationships with deprivation (0.001), participation in unpaid service (0.006), and proportional dwelling change (0.002), were all found to be highly statistically-significant, whilst the ethnic heterogeneity variable (0.039) was only weakly significant. Variables representing post-disaster increases in immigrant populations, alcohol accessibility, and socioeconomic inequality all proved non-significant.

The binary logistic model for burglary identified three significant relationships. Percentage unemployed (-125.4), residential mobility (-6.704), and the percentage change in occupied dwellings (-6.930) were all found to be negatively related to a greater than natural change in burglary. That is to say that in areas with lower unemployment, lower residential mobility, and where the number of occupied dwellings decreased (between 2006 and 2013), the change in burglary rates was more likely to be greater than that experienced prior to the

Canterbury Earthquakes. The NZDep Index was found to be non-significant in this model, and a selection of its components were tested in its place (family income, unemployment and residential mobility). The relationships with unemployment percentage (0.003) and post-earthquake dwelling change (0.000) were highly statistically-significant, whilst residential mobility was only weakly significant (0.040). Variables measuring median family income, single parent households, ethnic and socioeconomic heterogeneity, participation in unpaid service activities, and increases in overseas-born residents were all found to be non-significant.

In the binomial logistic models for both domestic violence and arson, no statistically-significant relationships were identified with the any independent variables. That is to say, that all combinations of independent variables were found to be non-significant in predicting areas that experienced changes in domestic violence and arson rates that were above or below that experienced prior to the Canterbury Earthquakes. The lack of observed significant relationships indicates that abnormal changes in domestic violence and arson rates were not able to be effectively predicted by the variables used, such as deprivation, ethnic and socioeconomic heterogeneity, earthquake damage/effects, presence of the Residential Red Zone, and increased overseas-born residents.

Table 18 Results of binary logistic regression models

Variables ¹ Base Category 0	Assault				Domestic Violence				Burglary				Arson				
	Estimate	Std. Error	z value	Pr (> z)	Estimate	Std. Error	z value	Pr (> z)	Estimate	Std. Error	z value	Pr (> z)	Estimate	Std. Error	z value	Pr (> z)	
NZDep	-0.030	0.009	-3.421	0.001***	0.004	0.006	0.655	0.512	-	-	-	-	0.002	0.008	0.253	0.800	
Median family income	-	-	-	-	-	-	-	-	0.000	0.000	0.582	0.560	-	-	-	-	
% Unemployed	-	-	-	-	-	-	-	-	-125.400	42.850	-2.927	0.003**	-	-	-	-	
Residential mobility	-	-	-	-	-	-	-	-	-6.704	3.271	-2.050	0.040*	-	-	-	-	
Ethnic heterogeneity [1] ²	0.002	0.001	2.060	0.039*	-	-	-	-	-	-	-	-	-	-	-	-	
Ethnic heterogeneity [2] ³	-	-	-	-	-1.531	4.226	-0.362	0.717	-	-	-	-	-	-	-	-	
ICE [2] ⁴	-	-	-	-	-	-	-	-	-8.563	5.713	-1.499	0.134	2.072	2.613	0.793	0.428	
% Unpaid service	-16.721	6.053	-2.762	0.006**	-2.553	6.130	-0.417	0.677	-	-	-	-	-	-	-	-	
% Volunteering	-	-	-	-	-	-	-	-	-0.543	12.070	-0.045	0.964	8.318	10.028	0.829	0.407	
% Dwelling change	-3.951	1.245	-3.174	0.002**	0.560	1.009	0.556	0.578	-6.930	1.950	-3.555	0.000***	-0.431	0.890	-0.484	0.628	
% Change in foreign born	11.047	8.423	1.311	0.190	-2.021	7.401	-0.273	0.785	-5.684	8.208	-0.693	0.489	4.040	7.849	0.515	0.607	
Alcohol outlet density ⁵	0.005	0.046	0.113	0.910	-0.026	0.040	-0.649	0.516	-	-	-	-	-0.005	0.006	-0.727	0.467	
Null Deviance		159.95 on 115 DOF				143.70 on 115 DOF				152.96 on 115 DOF				160.26 on 115 DOF			
Residual Deviance		135.89 on 109 DOF				142.34 on 109 DOF				125.84 on 108 DOF				152.58 on 109 DOF			
AIC		149.89				156.34				141.84				166.58			
* Significant to the 0.05 level																	
** Significant to the 0.01 level																	
*** Significant to the 0.001 level																	

¹Variable choice was based on the theoretical framework and the presence of significant relationships

²Measure of relative Maori population

³Measure of percentage of minority population

⁴Measure of relative proportions of families with \$100K annual income and those with less than \$30K annual income

⁵Measure of number of on- and off-license alcohol outlets per square kilometre

Following the running of the multinomial and binomial logistic regression models, a Moran's I test was employed to test for spatial autocorrelation in the residuals of each model. Moran's I values of the multinomial logistic regression and the binary logistic regression models are shown in Tables 19 and 20. Based on the results, statistically-significant spatial autocorrelation was identified in only three of the eight models. In the multinomial logistic models, significant spatial autocorrelation was detected for the burglary (Moran's I of 0.16749) and arson models (Moran's I of 0.11511), indicating a tendency towards the clustering of similar values (i.e. deviance values of the model). The testing of the binomial logistic models indicated the presence of spatial autocorrelation in only the burglary model (Moran's I of 0.18471). The presence of statistically-significant spatial autocorrelation indicates a spatial dependence or influence in the three identified regression models. As such the interpretation of those three models must be cautioned, and prefaced with this dependence.

Table 19 Moran's I testing of multinomial logistic regression residuals

	Variable	Moran's I	Z-Score	P-Value
Deviance residuals from multinomial logistic regression models	Assault	0.02149	0.55887	0.57625
	Domestic Violence	-0.0184	-0.1797	0.85738
	Burglary	0.16749	3.27348	0.001062**
	Arson	0.11511	2.30368	0.021241*
* Significant to the 0.05 level				
** Significant to the 0.01 level				

Table 20 Moran's I testing of binomial logistic regression residuals

	Variable	Moran's I	Z-Score	P-Value
Deviance residuals from binomial logistic regression models	Assault	0.029	0.69895	0.48458
	Domestic Violence	0.01559	0.45072	0.65219
	Burglary	0.18471	3.5906	0.00033**
	Arson	-0.0474	-0.7169	0.47342
* Significant to the 0.05 level				
** Significant to the 0.01 level				

Chapter 6 Discussion

The following chapter discusses the key findings of this research with respect to previous disaster-crime research, as well as the theoretical concepts thought to influence post-disaster offending trends. The key findings from this research are discussed and compared to previous international work, and criminological theory. Last, the limitations of this research and directions for future research are provided.

6.1 Discussion of findings

Maintenance of social order

Natural disasters have frequently been framed as prime opportunities for criminality to prevail in the absence of social order. Following the Canterbury Earthquakes, moderate-term trends of assault, burglary, and arson rates in Christchurch were found to decrease relative to pre-earthquake rates. Domestic violence was the sole exception, showing a gradual increase beginning around five months after the Christchurch Earthquake. In the months following Christchurch Earthquake, a distinct lull occurred in crime rates of all four offences. Such temporary decreases have also been noted by Leitner et al. (2011) in the counties of Louisiana after Hurricane Katrina for both violent and property crime. In general, these findings are consistent with other past research that has argued that widespread outbreaks of crime are more often sensationalised by the media, and that crime actually decreases following a disaster (see Barsky et al., 2006; Cromwell et al., 1995; Leitner et al., 2011; Watanabe & Tamura, 1995; Zahran et al., 2009). Though findings indicate that domestic violence increased after the Canterbury Earthquakes, such a trend is not unique, and its distinction from other offending trends after a disaster has also been found by Zahran et al. (2009). The significance of this increase is discussed later.

In contradiction to the aforementioned findings, a momentary increase in burglary was observed following the Christchurch Earthquake. Similar temporary increases in property crime, coincident with disasters, have been observed (Leitner & Helbich, 2011; Walker et al., 2012, 2014), and are often related (particularly burglary) to the ongoing discussion surrounding opportunistic looting (Barsky et al., 2006; Gray & Wilson, 1984; Quarantelli, 1994;

Siman, 1977). The burglary rate for the day of the Christchurch Earthquake was double that of the day prior (a total of 44 offences across the entire city), and remained elevated for a further eight days. This increase was far less apparent at a monthly scale, with February (2011) being only 6.8 percent higher than January, and was a mere 1.9 percent above the second highest burglary rate observed (August 2010). These figures would suggest that this spike in burglary was neither considerable nor enduring.

There was insufficient time to analyse the nature of this increase in burglary, and specifically where these crimes were committed, the value of items stolen, or whether or not the victimised homes were inhabited or uninhabited at the time (due to earthquake damage). Though mixed, this spike in burglary would suggest that some limited opportunistic property offending may have taken place in the immediate aftermath of the Christchurch Earthquake. Considering the debates around looting, this increase provides some limited support, though this burglary was neither widespread, nor indicative of an outbreak of mass crime.

Though the longer-term effects of the earlier Darfield Earthquake cannot be known due to the occurrence of the Christchurch Earthquake a mere five months later, available data suggests its effects on crime were far less than the Christchurch event. Though daily offence rates fluctuated substantially following the Christchurch Earthquake, variations following the Darfield event were comparably modest. From the observations available I theorise that the changes in criminal offending were in some way related to the intensity of each disaster event, where the Christchurch Earthquake had a greater intensity of physical and social effects. Such an assertion may hold significant consequences given that both physical and social effects of the Canterbury Earthquakes varied throughout the city, and that substantial changes in spatial patterns of offending were also observed (Renouf, 2012).

A further consideration around the apparent maintenance of social order was the presence of capable guardianship. Whilst the absence of formal guardians (namely law enforcement) after a disaster have been acknowledged previously (see Cromwell et al., 1995), others have also noted cases in which the number of formal guardians has increased. Specific examples have referenced the presence of the US's National Guard in exerting social control in areas struck by natural disasters (see Cromwell et al., 1995; Lee, 2010; Leitner et al., 2011). In a similar manner, law enforcement became preoccupied with aid, and search and rescue operations after the Christchurch Earthquake, leading to the deployment of the New Zealand

Army and foreign law enforcement officers. Although the significance of these external parties were not directly tested in this research, their presence may have influenced the reduction in offending in Christchurch after the Canterbury Earthquakes by increasing the level (or at least the perceived level) of formal guardianship. Like past examples in the US, these parties acted as guardians and likely deterred and prevented opportunistic offenders, particularly in the CBD where the New Zealand Army maintained the CBD Cordon, preventing access to the largely uninhabited central city.

The findings of this research suggest that the Canterbury Earthquakes, and the Christchurch event in particular, did not produce any significant loss of social order. Aside from a minimal and temporary increase in burglary immediately after the Christchurch Earthquake, crime decreased both in the short- and moderate-term, supporting the view that criminal behaviours decrease after a disaster.

Community response and social organisation

The role of communities in controlling social behaviours following a disaster has been stressed by many researchers (Auf Der Heide, 2004; Leitner et al., 2011; Miller, 2007; Munasinghe, 2007; Quarantelli, 1994; Zahran et al., 2009). Through increased collective efficacy and pro-social behaviours after a disaster, communities are theorised to be brought closer together, increasing their levels of social control, reducing the willingness to offend against one another, and enhancing levels of informal guardianship. The reduction of crime rates (except for domestic violence), and the temporary reduction of offending (across all four offences) after the Christchurch Earthquake support this notion of community cohesiveness in reducing offending post-disaster.

Similar to Leitner and Helbich (2011), more deprived areas were associated with a greater than average change in burglary and domestic violence, however a negative relationship was found for assault and arson. Lower residential mobility was associated with a greater than natural change in burglary; a finding supported by Walker et al. (2014) with larceny theft. Similar to Leitner and Helbich (2011) and Walker et al. (2012, 2014), an association was found between lower ethnic heterogeneity and a lower than average and lower than natural change in assault. A final social disorganisation variable, participation in unpaid activities was found to be associated with a greater than natural increase in assault.

Together, the regression results provide both support and opposition to the notion that areas with stronger communities are less vulnerable to relative increases in crime post-disaster. The associations found with traditional measures of social disorganisation were at times in contrast to those generally established and accepted by criminology academics. Specifically, deprivation and unpaid service variables varied between offence types and from expectations, suggesting that the idea of community cohesion and social disorganisation may be more complex than the measures offered here and in past works would suggest.

This research provides mixed evidence of the assertion that stronger communities were more able to control offending. As such, this does not prove nor disprove the influence of communities in post-disaster offending. Given the city-wide observation of a general decrease in crime following the Canterbury Earthquakes, it is suggested that such mechanisms did in fact occur, but were not able to be measured in this analysis. Further support of these ideas of increased collective efficacy can be found in the comments of Marlowe and Lou (2013), who noted that the Canterbury Earthquakes (at least partially) removed some of the perceived social boundaries between minority cultural groups and their neighbours.

Observing a similar decrease in offending in Louisiana following Hurricane Katrina, Leitner et al. (2011) remarked that this decrease was only temporary, and eventually returned to similar and even higher levels of offending. Given that this research only observed criminal offending until June 2013, criminal trends were observed for less than three years after the Christchurch Earthquake. As such, it is unknown how long these proposed community effects on crime may last.

Breakdown of communities

Prior research suggests that population displacement can lead to increased levels of offending post-disaster (Bass, 2008; Leitner et al., 2011; Varano et al., 2010). Though crime mainly decreased after the Canterbury Earthquakes, the influence of community disruption was investigated on a more localised level. Specifically the notion that strong communities are more able to control crime through informal social control and informal guardianship was investigated. The Residential Red Zone, and areas receiving large numbers of new residents were variables that were tested on the expectation that community disruption in these areas

would facilitate an increase of crime as a result of decreased informal guardianship and increased social disorganisation.

Measures of increased immigrant populations were found to be non-significant in all regression models, refuting popular assertions in Christchurch that foreign workers were responsible for increases in crime (Dally, 2013b). Conversely, the level of earthquake damage was found to be highly significant in predicting a greater than average and greater than natural increase in burglary and assault. This paralleled Walker's (et al., 2012) identification of a relationship between greater numbers of vacant buildings and a post-disaster increase in burglary.

I propose two explanations for this finding. First, that these areas suffering the greatest levels of earthquake damage were made susceptible to increased burglary victimisation as earthquake damage reduced elements of structural guardianship, such as windows or doors, as suggested by Gray and Wilson (1984) and Watanabe and Tamura (1995). Secondly, that in areas where earthquake damage was most severe, communities became disrupted and fragmented, as its members were forced to leave damaged homes, replaced by new and unfamiliar residents, or left uninhabited. As a result of this population loss, social and community bonds (critical in maintaining the strength of communities) were broken, introducing social disorganisation, and diminishing the community's influence over remaining residents (Sampson & Groves, 1989). With this fragmentation, levels of informal guardianship were reduced, either physically from the loss of neighbours, or due to an unwillingness to look out for new residents (Cromwell et al., 1995; Leitner et al., 2011; Varano et al., 2010). As a result of decreased informal guardianship, crime was left to flourish in the absence of neighbours looking out for one another's property and safety.

Domestic violence

Despite the substantial conjecture that surrounds changes in criminal offending after a natural disaster, increases in domestic violence have been one of the only trends that has received consistent support (see Adams & Adams, 1984; Enarson, 1999; Fothergill, 1996; LeBeau, 2002; Morrow, 1997). A post-disaster increase in domestic violence offences was again found in this research, albeit at a gradual rate, becoming 50 percent higher than the monthly average prior to the Canterbury Earthquakes. Notably, this longer-term increase in

domestic violence was in stark contrast to the more immediate decreases in assault, arson, and burglary, mirroring a similar result found by Zahran et al. (2009), who suggested that the domestic context isolated these offences from the same external mechanisms thought to influence other types of crime.

Previous observations of post-disaster increases in domestic abuse have been attributed to increased levels of stress (Adams & Adams, 1984; LeBeau, 2002). Considering Strain Theory and its past application to disaster contexts (Robertson et al., 2010), I propose that the Canterbury Earthquakes acted as an external stressor to residents, resulting in the observed increase of domestic abuse. Increases in stress, anxiety, and other psychological disorders, associated with the Canterbury Earthquakes have been noted by scholars (Gawith, 2013; Osman et al., 2012; Renouf, 2012; Sullivan & Wong, 2011). These authors identified ongoing aftershocks, personal loss, physical health issues, and financial hardships relating to earthquake damage, as sources of increased stress. As domestic abuse in Christchurch only increased sometime after the Christchurch Earthquake, it would not be unreasonable to assume that residents were able to cope with this increased stress initially, though after an extended period of time and its accumulation, the increased stress resulted in domestic abuse.

Examining the localised variation in the changes in domestic violence rates over Christchurch, the CBD and Residential Red Zone areas showed the greatest decreases in domestic abuse, likely as a result of the reduction in the resident population in these areas. The regression analysis identified a single significant relationship between relative increases in domestic violence and higher deprivation. One explanation of this may be that residents in these more deprived areas were more susceptible to the financial hardships created by the Canterbury Earthquakes, and as a result suffered greater increases in stress than the more affluent. Alternately, the more affluent may have been equally afflicted with similar stresses, but had the financial means to move away, masking such a relationship.

Aside from deprivation, no other associations were identified with predicted variables, including measures of alcohol accessibility, and level of earthquake damage. Given the absence of these relationships, a number of explanations are possible: firstly that no such relationship exists at the neighbourhood level and that these relationships may only be observable at an individual level; or secondly, that the substantial population movement after

the Canterbury Earthquakes disrupted such observations. An association between increases in domestic violence and earthquake damage was expected, due to the increased financial and related stresses associated with earthquake damage and loss. I propose that the regression analysis was limited in this respect, as those most severely affected by earthquake damage would more likely want or need to leave their homes, and as a result remove the presence of such a relationship. As such, further study of domestic violence should not dismiss such a link, but instead make use of non-ecological and/or qualitative methods.

Spatial changes in crime

Compared to past disaster-crime works that have examined short-term changes in the spatial patterns of crime following a disaster (see Leitner & Helbich, 2011; Walker et al., 2012, 2014), this research worked to identify similar moderate-term changes. Rather than compare the immediate changes in crime distributions after the Canterbury Earthquakes, this research found that in the years following the Canterbury Earthquakes, there was a distinct spatial change in crime patterns that could not be examined at a city-wide scale. The spatial distribution of offending varied markedly following the Canterbury Earthquakes for all four studied offence types. These changes were most obvious in areas such as the CBD, the Residential Red Zone, and in many of the suburbs near to the central city, such as Riccarton and Addington, and the Eastern suburbs.

Given this distinct change in offending patterns, I suggest an explanation in keeping with Routine Activity Theory specifically that the Canterbury Earthquakes resulted in considerable changes to the routine activities of Christchurch's residents, changing the locations of offending hotspots. Routine Activity Theory states that a crime will only occur when motivated offenders, suitable targets, and an absence of capable guardianship converge in both time and space (Cohen & Felson, 1979). Given that the effects of the Canterbury Earthquakes resulted in widespread changes to the three core locations included in Routine Activity Theory (places of residence, work, and recreation), it is not unfeasible to suggest that with mass changes in a population's routine activities, the distribution of offence locations would shift as a result. That is to say, if a person was to be assaulted along their commute to their place of work that the likely places of convergence for this crime to occur would change in relation to this person's place of work moving as a result of the Canterbury Earthquakes.

Considering this idea across the entire city, the mass removal of workplaces from the CBD, widespread changes from prior places of residence, and the movement of retail and hospitality businesses has affected the presence of victims, offenders, and guardians in these locations, in turn affecting both the likelihood of convergence. More specifically, the CBD cordon that prevented access to the central city following the Christchurch Earthquake (that was in place until June 2013) greatly affected businesses (such as bars and retail), forcing most to move outside of the CBD, may have been responsible for increases in crime in peripheral areas, such as assault in Riccarton and Addington. Additional assessment of these trends will need to be made in the future, as development in Christchurch continues, and whilst areas such as the CBD regain use, other areas may become hubs of activity further influencing the spatial variations in offending already observed.

Comparison to media reports

As with many major natural disasters, trends and changes in criminal offending after the Canterbury Earthquakes became a major focal point of media coverage. To facilitate an impartial and objective assessment of the accuracy of the media's portrayal of crime, a number of key trends were distilled from a sample of these media reports that included:

- An increase of burglary and arson offending in the Residential Red Zone
- The movement of violent crime away from the central city and into nearby suburbs
- An increase in domestic violence

The localised increase in burglary in the Residential Red Zone, referred to in the media post-earthquake (see Ensor, 2013; Gates, 2012; Heather & Lynch, 2012; Hume & Robinson, 2015), was largely supported in the findings of this research. Though overall burglary rates fell across the entire study period, density maps of burglary highlighted a post-disaster increase in a number of locales, perhaps most significantly in the Residential Red Zone. The results of the regression analysis suggest that the decreases in dwelling occupation in these neighbourhoods could explain the increases in burglary. The similarly reported rise of arson in the Residential Red Zone and other abandoned areas was however not supported by the research findings. This suggests that although media reports of increased burglary in the Residential Red Zone were to some extent justified, reports of arson targeting the Residential Red Zone may have been over-exaggerated.

According to media reports (see Dally, 2013b; Ensor, 2013; Lynch, 2011b; Mathewson, 2012), there was an apparent spatial diffusion of assault from pre-earthquake hotspots such as the CBD, into nearby peripheral areas such as Riccarton, Addington, Hornby, and Shirley East following the Canterbury Earthquakes. The results of the DKDE analysis of assault support supported this, demonstrating an enormous deficit of assault offences in the CBD, whilst simultaneously increasing in the same areas mentioned by the media. These same reports linked reported post-earthquake increases in violent offending (particularly in the Riccarton area) to alcohol consumption, a link that was unexpectedly refuted in the regression findings. The findings in fact support an inverse relationship between a relative increase in assault and alcohol accessibility, though due to the nature of the method (not directly measuring the influence of alcohol on offences) this does not preclude the influence of alcohol on these relative increases. Instead, this finding may be indicative of the movement of alcohol-related behaviours away from previous clusters of on-license premises (namely bars) and into suburban areas that have far lower measured alcohol accessibility. This suggestion would support reports such as Lynch (2011b) that attributed an increase in drunken behaviour and public disorder to an increase in suburban locations for social activities.

The reported rise in domestic violence in Christchurch following the Canterbury Earthquakes (see Carville, 2011; “Crime spreads in Canterbury,” 2011; Lynch, 2011a; Stylianou, 2011) was definitely supported in the research findings, with a 52.7 percent increase in offending on pre-earthquake average levels.

Overall the findings of this research largely support the information and accounts provided through local media with some notable differences. This finding is somewhat rare, as Gray and Wilson (1984) and Quarantelli (1994) remark that post-disaster criminal behaviour is often sensationalised by the media, which in turn influences public perception about increased criminal activity.

6.2 Limitations

The limitations of this study are acknowledged below. Each limitation is detailed as to its significance, and the steps taken to mitigate and reduce its bearing on the quality and validity of the findings of this research.

Scale of analysis

Both the thematic and spatial aggregations of data used in this research are acknowledged as limitations. Due to time constraints, the analysis was limited to four high-level offence types (assault, domestic violence, burglary, and arson). The offence data was analysed only at this level of thematic aggregation and not explored in greater detail meaning that micro trends in offending could not be observed as part of this research. Whilst it may have been preferable to break down these groupings into finer offence types to explore more specific relationships, such as alcohol-related assaults or looting-related burglaries, there was not sufficient time. This limitation serves as a prominent avenue for future research, as no conclusions were drawn in this research regarding crime beyond the broad groupings of assault, domestic violence, burglary, and arson.

Spatial aggregation serves as another limitation to this work. Whilst the spatio-temporal analysis was performed at an offence-level, both the temporal and regression analyses were carried out at an aggregate level. Whilst the aggregation of offence data to administratively-defined areas is often a necessity and has its advantages, it remains a limitation of this work as findings (particularly associations found in the regression analysis) were not found at an individual-level. Furthermore, due to the availability and confidentiality restrictions surrounding population estimates and census data, the CAU level of aggregation was used. This increased the number of available independent variables, and permitted the use of sub-census interval population figures for the creation of accurate crime rates. As a result, the areas of analysis can be substantial in spatial area in some CAUs, and some patterns may have been lost as a result. A further disadvantage of using the CAU aggregation was that was that Christchurch contained only 116 areas. Had the finer Meshblock aggregation been used, the regression analysis may have been improved as a result of the increased sample number, however this would have also restricted the data available to create the independent variables, greatly reducing the breadth of this work.

Edge effect

Though minor in this study, the common spatial issue of edge effects is a noted limitation of this study. Edge effects are created as a result of the imposition of administrative boundaries on analyses, when phenomena extend beyond and through these bounds (see Gatrell, Bailey, Diggle, Rowlingson, & Rowlingsont, 1996). Any observations made may be unduly biased, or

misrepresentative when areas outside of these bounds are excluded from the spatio-temporal analysis. These edge effects are particularly prominent in Kernel Density Estimation-based analyses. In restricting the Kernel Density analysis to the city boundary of Christchurch, data outside this area was excluded, meaning that the search window could not interpolate data beyond this, leaving these edge-adjacent areas potentially lower in value than if the boundary had not been imposed. It should be noted however that the areas immediately outside the city boundary of Christchurch are near-exclusively rural, or natural boundaries (such as coastlines), reducing the significance of edge effects, as these areas are unlikely to be areas of high nor influential offending. Moreover, the primary areas of interest are located near to the centre of Christchurch, making any corrections for edge effects of little consequence for the substantive aim of this research.

Data quality

The fourth limitation of this research relates to the level of authenticity and accuracy of the crime data. Despite its near universal use in criminological research, scholars have long commented on the accuracy and reliability of official crime statistics in the representation of crime (MacDonald, 2002; Sampson & Groves, 1989; Skogan, 1974). Sampson and Groves (1989) suggest that lower socioeconomic areas are overrepresented in crime statistics, at least in-part, due to a heightened police presence in these areas. Non-reporting has also been shown to be significant in the accuracy of offence recording, which is particularly prominent in cases of rape and domestic violence. Researchers have also cited a lack of faith in police procedures, a loss of privacy, and the societal stigma surrounding rape as decreasing the likelihood of victims reporting rape offences (Felson & Paré, 2005; Stone et al. as cited in Pawson & Banks, 1993). Similarly, non-reporting of domestic violence has been related to a loss of privacy, fear of further offending as acts of reprisal, gender-based stigmas, and a reluctance to report their domestic partner, as motivation (Felson, Messner, Hoskin, & Deane, 2002; Felson & Paré, 2005; Zahran et al., 2009). Lastly, police discretion is thought to further the uncertainty present in crime records, considering available evidence and the seriousness of the crime (Boivin & Cordeau, 2011; MacDonald, 2002).

Researchers have raised further concerns for the quality of crime statistics recorded during and after natural disasters (see Barsky et al., 2006; Cromwell et al., 1995; LeBeau, 2002; Leitner et al., 2011; Quarantelli, 1994; Siman, 1977). The major concerns relate to the fact

that reporting of crime to Police is inhibited by damage to communications and reporting infrastructure, such as the loss of phone lines and power supply (Cromwell et al., 1995). Second, that law enforcement agencies may become more concerned with the provision of disaster relief rather than the recording of crime (Cromwell et al., 1995; Siman, 1977). In this same vein, other scholars have proposed a relaxation in the discretion and enforcement of offences by law enforcement in consideration of other prioritised tasks and overwhelming workloads in the aftermath of disasters (Barsky, 2006; LeBeau, 2002; Quarantelli, 1994). Given the context of this research, this limitation is inherent and in no way different from similar research (see Cromwell et al., 1995; Leitner et al., 2011). With a large portion of this research investigating longer-term trends in offending, this limitation becomes less critical, assuming that the pre- and post-disaster periods examined would likely contain similar levels of reporting biases, under- and over-reporting, and error.

Independent variables

The fifth limitation relates to the quality and representation of the phenomena measured by the independent variables. Where possible, these variables were developed using established measures based on prior works to ensure the highest level of comparability to past research. One such example was in the definition of a variable to represent the Index of Concentration at the Extremes (ICE) (as defined by Massey, 2001). Applying ICE to this research was difficult given that the socioeconomic context is substantially different to the US (where it was developed) and furthermore there is no official poverty line defined in New Zealand. Additionally given the available data around family income the ICE variable was impossible to fully replicate, and as a result three different ICE variables were created using different income thresholds in an attempt to test the same principles of socioeconomic inequality.

A further example of the difficulties experienced in creating independent variables was in the representation of earthquake damage in residential areas, given the absence of suitable data on residential demolitions or building assessments. Instead proxy variables were created to approximate this phenomena, using data of occupied dwellings. Similarly, population turnover in Christchurch was difficult to represent in the analysis, particularly in separating natural migration in and away from Christchurch from that drawn to the region by employment opportunities (a group of interest in this research).

Spatial autocorrelation

The final limitation of this work relates to the spatial dependence in the data analysed. As previously identified, statistically-significant spatial autocorrelation was found in three of the final regression models (multinomial: burglary and arson, and binary: burglary). The presence of spatial autocorrelation is indicative of spatial dependence in a regression model, violating one of the assumptions of logistic regression. In most cases spatial dependence is mitigated for with the application of a spatial regression model. These spatial regression models however are frequently built from Ordinary Least Squares models, and are less frequently applied to logistic regression models. As such spatial logistic regression model have seen little use in criminology research.

Various options were explored and trialled to account for the spatial autocorrelation in three of the models in this research, though none were undertaken due to the time constraints of this work. Both the R library SpatStat, and the GeoDa Centre's GWR4 software offered logistic regression models with a spatial component, however neither offered the ability to use area-based data. Whilst a conversion of the CAU data for Christchurch to population-weighted centroids was an option, difficulties were presented regarding the conceptualisation of spatial relationships given that upon conversion to point data, boundary contiguity was naturally lost. This meant that any spatial components accounted for by these spatial logistic regression models would have been different to those in which the spatial autocorrelation was initially identified. Lastly, these libraries are only able to create binary logistic regression models, severely limiting their usefulness to this research, given that two of the models in question are multinomial.

A third option presents the most promising line of solution to the presence spatial dependence of three of the present regression models. Conditional AutoRegressive Bayesian modelling (CARBayes) is a modelling technique that is able to utilise area-based spatial data in the computation of both binomial and multinomial logistic regression models. Time constraints prevented this option from being fully explored and tested, though this serves as the primary direction of future work in this research, adding a greater level of validity to the three regression models that contained spatial autocorrelation in their residuals.

6.3 Future work

This research has been the first to empirically assess the impacts of the Canterbury Earthquakes on the spatio-temporal distribution of crime in the city. In fact, it is the first ever study in Australasia to assess the impact of an earthquake event on the spatial patterning of crime. The analysis and results have provided an initial assessment of how criminal offending patterns have changed following the Canterbury Earthquakes, and hopefully provides a basis upon which further research can be undertaken.

This research focused on four broad offence types that were informed by past disaster-crime research as well as media attention that sensationalised post-earthquake offending in Christchurch. Future work should expand upon this limited group of offence types to include offences such as theft and vehicle theft, which have proven to be significantly impacted by disaster events (see Leitner & Helbich, 2011; Walker et al., 2012, 2014). Furthermore, a more in depth investigation of more specific crimes such as trends in alcohol- and drug-influenced crime, and the nature of burglary offending in areas such as the Residential Red Zone. At a later date it may be pertinent to perform a longitudinal analysis over a much longer period to truly understand the ultimate long-term implications of the Canterbury Earthquakes on crime.

Limitations with present data have meant that population movement in Christchurch has only been superficially addressed in this work. Considering a number of significant past works have specifically addressed disaster-related population movement and its effects, further research of this nature could examine the influx of immigrant workers on crime patterns. Research into criminal behaviour and the mental health of residents who left Christchurch after the Canterbury Earthquakes may also be of value in order to understand how personal reactions differed between individuals experiencing both the short- and long-term earthquake effects versus an individual who has more limited exposure.

Past disaster-crime work has placed an emphasis on the importance of qualitative research to ascertain individual-level accounts of post-disaster victimisation and perceptions of crime (Gray & Wilson, 1984; Siman, 1977; Watanabe & Tamura, 1995). Similar work would be of particular relevance to the earlier reconciliation of media reported criminal trends and the actuality.

Chapter 7 Conclusion

This research has provided the first insight into the effects of the Canterbury Earthquakes on criminal behaviours and patterns in Christchurch. Following the devastation caused by the Christchurch Earthquake (February 2011), and the ongoing disruption that followed the thousands of aftershocks, crime proved to be at the forefront of the public's mind, fed by media reports of assault moving away from the central city and the a rise in property crimes (namely burglary and arson) in the eastern suburbs. This research sought to provide an objective examination of the changes in criminal behaviours and patterns following the Canterbury Earthquakes.

Research of crime during and after disasters has been plentiful, particularly in the study of crime in the immediate aftermaths of US hurricanes. Despite numerous works across different natural disasters in different countries, there has been a great amount of variation and only minimal consensus as to how criminal offending is affected by natural disasters. What consensus exists argues that against popular belief, crime generally decreases after a disaster (see Barsky et al., 2006; Cromwell et al., 1995; Leitner et al., 2011; Leitner & Guo, 2013; Watanabe & Tamura, 1995). Many factors have been suggested as influencing this trend, including the large scale increase of collective efficacy that results in the increased presence and potency of informal guardianship (see Auf Der Heide, 2004; Leitner et al., 2011; Miller, 2007; Munasinghe, 2007; Quarantelli, 1994; Zahran et al., 2009). Domestic violence has been anomalous in this regard, having been found to (comparatively) consistently increase following a disaster (see Adams & Adams, 1984; Enarson, 1999; Fothergill, 1996; LeBeau, 2002; Morrow, 1997; Zahran et al., 2009).

Thus this research was framed with three research objectives:

- 1) Definitively identify the short- and moderate-term temporal trends in crime in relation to the events of the Canterbury Earthquakes.
- 2) Map and identify areas of the greatest spatial variability of crime change following the Canterbury Earthquakes
- 3) Understand and predict the areas which saw increased or decreased criminal activity using regression modelling and ecological variables.

To accomplish these objectives, a multi-staged analysis was carried out investigating assault, domestic violence, burglary, and arson with; (1) a city-wide longitudinal analysis of offending, (2) an examination of moderate-term spatial changes in offending using Kernel Density Estimation, and (3) a regression analysis to understand changes in offending.

Overall, general crime was found to decrease in the months and years after the Canterbury Earthquakes, albeit after a momentary increase in burglary offences immediately after the Christchurch Earthquake. In-line with past findings, domestic violence reacted distinctly from the other offence types, gradually increasing in the months after the Canterbury Earthquakes. Beyond these city-wide trends, post-earthquake changes in crime varied greatly in terms of offence locations and concentrations. Most significantly, burglary and assault demonstrated distinctly different spatial patterns following the Canterbury Earthquakes that were consistent with media reports of increased assault outside of the central city, and increased burglary in the Residential Red Zone. Notably, no evidence was found of a similar movement and increase of arson in the Red Zone. Surprisingly, media reports very accurately represented the observed reality of post-earthquake crime trends, in stark contrast to the findings of Gray and Wilson (1984), and Quarantelli (1994).

Seeking to understand the temporal and spatial variations in crime following the Canterbury Earthquakes, a temporally-adjusted logistic regression analysis compared localised crime rate change to variables used to represent ideas of Social Disorganisation, Routine Activity, and Strain Theory. Though model performance varied wildly, a number of statistically-significant relationships were identified with variables including; deprivation, ethnic heterogeneity, community involvement, earthquake damage, and the accessibility of alcohol.

The two most significant points of discussion surrounded the role of communities in reducing offending after a disaster and the role that disaster effects had in increasing offending. In-line with Social Disorganisation Theory and Routine Activity Theory, crime is thought to decrease following a disaster due to an increase in community cohesion and belonging, and increased altruism (see Auf Der Heide, 2004; Leitner et al., 2011; Miller, 2007; Munasinghe, 2007; Quarantelli, 1994; Zahran et al., 2009). Though crime generally decreased after the Canterbury Earthquakes, the regression findings provided mixed results in relating stronger communities to relative decreases in post-disaster offending, suggesting that such phenomena may be indeterminable through such measures. Secondly, a strong association

was found between decreases in occupied dwellings (a proxy measure of residential earthquake damage) and relative increases in burglary. An expected finding, this relationship lends support to ideas of reduced community cohesion and informal guardianship, where population numbers are heavily reduced.

Overall this research, provided a comprehensive exploration of how crime has changed in Christchurch following the Canterbury Earthquakes. Though findings proved to be mixed, in general crime behaved in a manner consistent with past research and the applications of theoretical frameworks established around disasters and crime. The Canterbury Earthquakes were found to have a substantial impact on offending patterns, though it remains to be seen how crime will change in the long-term.

References

- Adams, P. R., & Adams, G. R. (1984). Mount Saint Helens's ashfall. Evidence for a disaster stress reaction. *The American Psychologist*, 39(3), 252–260. <http://doi.org/10.1037/0003-066X.39.3.252>
- Agnew, R. (1992). Foundation for a General Strain Theory of Crime and Delinquency. *Criminology*, 30(1), 47–87. <http://doi.org/10.1111/j.1745-9125.1992.tb01093.x>
- Agnew, R. (2001). Building on the Foundation of General Strain Theory: Specifying the Types of Strain Most Likely to Lead to Crime and Delinquency. *Journal of Research in Crime and Delinquency*, 38(4), 319–361. <http://doi.org/0803973233>
- Anderson, C. (2013, November 28). Red-zone demo to deter crime. *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/9453283/Red-zone-demo-to-deter-crime>
- Atkinson, J., Salmond, C., & Crampton, P. (2014). *NZDep2013 Index of Deprivation*. Wellington. Retrieved from <http://www.otago.ac.nz/wellington/departments/publichealth/research/hirp/otago020194.html>
- Auf Der Heide, E. (2004). Common Misconceptions about disasters: Panic, the “Disaster Syndrome,” and Looting. In M. O’Leary (Ed.), *The First 72 Hours: A Community Approach to Disaster Preparedness* (pp. 340–380). iUniverse Publishing.
- Baird, M. E. (2010). *The “Phases” of Emergency Management*. Retrieved from <http://www.vanderbilt.edu/vector/research/emmgtp Phases.pdf>
- Bannister, S., & Gledhill, K. (2012). Evolution of the 2010–2012 Canterbury earthquake sequence. *New Zealand Journal of Geology and Geophysics*, 55(3), 295–304. <http://doi.org/10.1080/00288306.2012.680475>
- Barsky, L. (2006). “Hands off my property!”: An assessment of the local, national, and international print media’s portrayal of looting in disasters.
- Barsky, L., Trainor, J., & Torres, M. (2006). *Disaster Realities in the Aftermath of Hurricane Katrina: Revisiting the Looting Myth* (Vol. 184).
- Bass, L. J. (2008). A Pooled Time Series Analysis of Hurricane Katrina Evacuees and their Effect on Crime Rates. In *Annual Meeting of the MPSA Annual National Conference*.
- Boivin, R., & Cordeau, G. (2011). Measuring the Impact of Police Discretion on Official Crime Statistics: A Research Note. *Police Quarterly*, 14(2), 186–203. <http://doi.org/10.1177/1098611111404179>

- Breetzke, G. D., Pearson, A., & Conradson, D. (2013). *Examining the relationship between recorded crime and the fear of crime in Christchurch, New Zealand*. Christchurch.
- Breetzke, G. D., & Pearson, A. L. (2013). The fear factor: Examining the spatial variability of recorded crime on the fear of crime. *Applied Geography*, 46, 45–52. <http://doi.org/10.1016/j.apgeog.2013.10.009>
- Breetzke, G. D., & Pearson, A. L. (2014). The fear factor: Examining the spatial variability of recorded crime on the fear of crime. *Applied Geography*, 46, 45–52. <http://doi.org/10.1016/j.apgeog.2013.10.009>
- Carville, O. (2011, July 8). June quake fills women's refuges. *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/5253671/June-quake-fills-womens-refuges>
- Cayo, M. R., & Talbot, T. O. (2003). Positional error in automated geocoding of residential addresses. *International Journal of Health Geographics*, 2, 10. <http://doi.org/10.1186/1476-072X-2-10>
- Chainey, S., & Ratcliffe, J. (2005). *GIS and Crime Mapping*. West Sussex, England: John Wiley & Sons Ltd.
- Chang, S. E., Taylor, J. E., Elwood, K. J., Seville, E., Brunsdon, D., & Gartner, M. (2014). Urban disaster recovery in Christchurch: The central business district cordon and other critical decisions. *Earthquake Spectra*, 30(1), 513–532. <http://doi.org/10.1193/022413EQS050M>
- Chiricos, T., Eschholz, S., & Gertz, M. (1997). Crime, News and Fear of Crime: Toward an Identification of Audience Effects. *Social Problems*, 44(August), 342–357.
- Cohen, L. E., & Felson, M. (1979). Social Change and Crime Rate Trends: A Routine Activity Approach. *American Sociological Review*, 44(4), 588. <http://doi.org/10.2307/2094589>
- Conradson, V. (1996). The Experience of Crime in a Small Town: Lyttelton in 1995. *New Zealand Journal of Geography*, 1, 1–7.
- Crime spreads in Canterbury. (2011, April 6). *The Press*. Retrieved from <http://www.stuff.co.nz/national/christchurch-earthquake/4851687/Crime-spreads-in-Canterbury>
- Cromwell, P., Dunham, R., Akers, R., & Lanza-Kaduce, L. (1995). Routine activities and social control in the aftermath of a natural catastrophe. *European Journal on Criminal Policy and Research*, 3(3), 56–69. <http://doi.org/10.1007/BF02242928>
- Dally, J. (2013a, February 16). Christchurch dubbed “Arson City.” *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/8312171/Christchurch-dubbed-Arson-City>

- Dally, J. (2013b, October 2). Canty crime up 86 per cent. *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/canterbury/9232315/Canty-street-crime-up-86-per-cent>
- Davidson, R. N. (1980). Patterns of Residential Burglary in Christchurch. *New Zealand Geographer*, 36(2), 73–78.
- Davila, M., Marquart, J. W., & Mullings, J. L. (2005). Beyond Mother Nature: Contractor Fraud in the Wake of Natural Disasters. *Deviant Behavior*, 26(3), 271–293. <http://doi.org/10.1080/01639620590927623>
- Day, P., Breetzke, G. D., Kingham, S., & Campbell, M. (2012). Close proximity to alcohol outlets is associated with increased serious violent crime in New Zealand. *Australian and New Zealand Journal of Public Health*, 36(1), 48–54. <http://doi.org/10.1111/j.1753-6405.2012.00827.x>
- Enarson, E. (1999). Violence Against Women in Disasters: A Study of Domestic Violence Programs in the United States and Canada. *Violence Against Women*, 5(July), 742–768.
- Ensor, B. (2013, May 28). Quake changes Christchurch crime patterns. *The Press*.
- Ensor, B. (2014, May 26). Girl “breaks police officer”s glasses, nose’. *The Press*. Retrieved from <http://www.stuff.co.nz/national/crime/10083183/Girl-breaks-police-officers-glasses-nose>
- Federal Bureau of Investigation. (2004). *Uniform Crime Reporting Handbook*. U.S. Department of Justice. Retrieved from <http://www2.fbi.gov/ucr/killed/2009/aboutucr.html>
- Felson, R. B., Messner, S. F., Hoskin, A. W., & Deane, G. (2002). Reasons for Reporting and Not Reporting Domestic Violence To the Police. *Criminology*, 40(3), 617–648. <http://doi.org/10.1111/j.1745-9125.2002.tb00968.x>
- Felson, R. B., & Paré, P. P. (2005). The reporting of domestic violence and sexual assault by nonstrangers to the police. *Journal of Marriage and Family*, 67(3), 597–610. <http://doi.org/10.1111/j.1741-3737.2005.00156.x>
- Fothergill, A. (1996). Gender, Risk, and Disaster. *International Journal of Mass Emergencies and Disasters*.
- Frailing, K., & Harper, D. W. (2010). Crime and Hurricanes in New Orleans. In D. L. Brunson, D. Overfelt, & J. S. Picou (Eds.), *The Sociology of Katrina: Perspectives on a Modern Catastrophe* (2nd ed., pp. 55–74). Lanham, Maryland: Rowman & Littlefield Publishers, INC.
- Gates, C. (2012, August 17). Police say no cause for alarm on red-zone crime. *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/7493987/Police-say-no-cause-for-alarm-on-red-zone-crime>

- Gatrell, A. C., Bailey, T. C., Diggle, P. J., Rowlingson, B. S., & Rowlingson, B. S. (1996). Point Spatial application pattern analysis geographical epidemiology. *Transactions of the Institute of British Geographers*, 21(1), 256–274.
- Gawith, E. (Libby). (2013). The on-going psychological toll from the Canterbury earthquakes: Stories from one community. *Disaster Prevention and Management*, 22(5), 395–404. <http://doi.org/10.1108/DPM-10-2013-0180>
- Goldberg, D. W., Wilson, J. P., & Knoblock, C. a. (2007). From Text to Geographic Coordinates: The Current State of Geocoding. *URISA Journal*, 19, 33–46. <http://doi.org/10.1.1.119.714>
- Gray, J., & Wilson, E. (1984). *Looting in Disaster: A General Profile of Victimization*.
- Hagenauer, J., Helbich, M., & Leitner, M. (2011). Visualization of crime trajectories with self-organizing maps: a case study on evaluating the impact of hurricanes on spatio-temporal crime hotspots. ... of the 25th Conference of the ..., (August 2015). Retrieved from [http://www.icaci.org/files/documents/ICC_proceedings/ICC2011/Oral Presentations PDF/B4-Maps, GIS, security and planning/CO-173.pdf](http://www.icaci.org/files/documents/ICC_proceedings/ICC2011/Oral_Presentations_PDF/B4-Maps,_GIS,_security_and_planning/CO-173.pdf)
- Hayward, B. M. (2013). Rethinking resilience: Reflections on the earthquakes in Christchurch, New Zealand, 2010 and 2011. *Ecology and Society*, 18(4). <http://doi.org/10.5751/ES-05947-180437>
- Heath, L., & Gilbert, K. (1996). Mass Media and Fear of Crime. *American Behavioral Scientist*, 39(February), 379–386.
- Heather, B., & Lynch, K. (2012, January 4). Crime fears in emptying red zone. *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/6211268/Crime-fears-in-emptying-red-zone>
- Hipp, J. R. (2007). Income Inequality , Race , and Place Income Inequality , Race , and Place : Does the distribution of race and class within neighborhoods affect crime rates ? John R . Hipp * Word count (including references) : 9 , 339 Running Head : “ Income Inequality ,. *Criminology*, 45(3), 665–697.
- Hume, M., & Robinson, S. (2015, January 3). Christchurch’s red zone is like a “war zone”, some say. *The Press*. Retrieved from <http://www.stuff.co.nz/national/64626442/Christchurchs-red-zone-is-like-a-war-zone-some-say>
- Johnston, D., Standring, S., Ronan, K., Lindell, M., Wilson, T., Cousins, J., ... Bissell, R. (2014). The 2010/2011 Canterbury earthquakes: Context and cause of injury. *Natural Hazards*, 73(2), 627–637. <http://doi.org/10.1007/s11069-014-1094-7>
- Kubrin, C. E., & Stewart, E. a. (2006). Predicting who reoffends: The neglected role of neighborhood context in recidivism studies. *Criminology*, 44(1), 165–197.

<http://doi.org/10.1111/j.1745-9125.2006.00046.x>

- Lamichhane, A. P., Warren, J., Puett, R., Porter, D. E., Bottai, M., Mayer-Davis, E. J., & Liese, A. D. (2013). Spatial patterning of supermarkets and fast food outlets with respect to neighborhood characteristics. *Health & Place*, 23, 157–164. <http://doi.org/10.1016/j.healthplace.2013.07.002>
- LeBeau, J. L. (2002). The Impact of Hurricane On Routine Activities and on Calls for Police Service: Charlotte, North Carolina, and Hurricane Hugo. *Crime Prevention and Community Safety: An International Journal*, 4, 53–64. <http://doi.org/10.1057/palgrave.cpcs.8140114>
- Lee, Y. Y. (2010). Gentrification and crime: Identification using the 1994 northridge earthquake in los angeles. *Journal of Urban Affairs*, 32(5), 549–577. <http://doi.org/10.1111/j.1467-9906.2010.00506.x>
- Leitner, M., Barnett, M., Kent, J., & Barnett, T. (2011). The Impact of Hurricane Katrina on Reported Crimes in Louisiana: A Spatial and Temporal Analysis. *The Professional Geographer*, 63(2), 244–261. <http://doi.org/10.1080/00330124.2010.547156>
- Leitner, M., & Guo, D. (2013). Analyzing the Impact of One Important Unplanned Exceptional Event, Hurricanes, on Crime in Louisiana, U.S. Using a Visual Analytics Approach. In *GI-Forum 2013* (pp. 127–136). Herbert Wichmann Verlag, Heidelberg. <http://doi.org/10.1553/giscience2013s127.128>
- Leitner, M., & Helbich, M. (2009). Analyzing, Modeling, and Mapping the Impact of Hurricanes Katrina and Rita on the Spatial and Temporal Distribution of Crime in Houston, TX. In *GI-Forum*.
- Leitner, M., & Helbich, M. (2011). The Impact of Hurricanes on Crime: A Spatio-Temporal Analysis in the City of Houston, Texas. *Cartography and Geographic Information Science*, 38(2), 213–221. <http://doi.org/10.1559/15230406382213>
- Leitner, M., & Stauffer-steinnocher, P. (2001). Kernel density estimation: An innovative exploratory tool for geomarketing.
- Lewis, K. V. (2013). The power of interaction rituals: The Student Volunteer Army and the Christchurch earthquakes. *International Small Business Journal*, 31(7), 811–831. <http://doi.org/10.1177/0266242613478438>
- Lynch, K. (2011a, March 9). Spike in domestic violence after Christchurch earthquake. *The Press*. Retrieved from <http://www.stuff.co.nz/national/christchurch-earthquake/4745720/Spike-in-domestic-violence-after-Christchurch-earthquake>
- Lynch, K. (2011b, April 23). Riccarton residents had “gutsful.” *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/christchurch-earthquake->

2011/4919871/Riccarton-residents-had-gutsful

- MacDonald, Z. (2002). Official crime statistics: Their use and interpretation. *Economic Journal*, 112(477), 85–106. <http://doi.org/10.1111/1468-0297.00685>
- Marlowe, J. (2013). Resettled refugee community perspectives to the Canterbury earthquakes: Implications for organizational response. *Disaster Prevention and Management*, 22(5), 434–444. <http://doi.org/10.1108/DPM-01-2013-0019>
- Marlowe, J., & Lou, L. (2013). The Canterbury Earthquakes and refugee communities. *Aotearoa New Zealand Social Work*, 25(25), 58–68.
- Massey, D. S. (2001). The Prodigal Paradigm Returns: Ecology Comes Back to Sociology. *Does It Take a Village? Community Effects on Children, Adolescents, and Families*, (1995), 41–48.
- Mathewson, N. (2012, April 3). Sex crimes increase, with quakes blamed. *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/6682161/Sex-crimes-increase-with-quakes-blamed>
- McColl, G. J., & Burkle, F. M. J. (2012). and Recovery in Christchurch FROM THE FIELD. *Disaster Medicine and Public Health Preparedness*, 6(1), 33–43. <http://doi.org/http://dx.doi.org/10.1001/dmp.2012.8>
- McLean, I., Oughton, D., Ellis, S., Wakelin, B., & Rubin, C. B. (2012). Review of the Civil Defence Emergency Management Response to the 22 February Christchurch Earthquake, (June), 243.
- Miller, L. M. (2007). Collective disaster responses to Katrina and Rita: Exploring therapeutic community, social capital and social control. *Southern Rural Sociology*, 22(2), 45–63.
- Morenoff, J. D., Sampson, R. J., & Raudenbush, S. W. (2001). Neighbourhood Inequality, Collective Efficacy, and the Spatial Dynamics of Urban Violence. *Criminology*, 39(3), 517–561.
- Morrow, B. H. (1997). Stretching the Bonds: The families of Andrew. In W. G. Peacock, B. H. Morrow, & H. Gladwin (Eds.), *Hurricane Andrew: Ethnicity, gender and the sociology of disasters* (pp. 141–170). Routledge London and New York.
- Morrow, B. H., & Enarson, E. (1996). Hurricane Andrew Through Women's Eyes: Issues and Recommendations. *International Journal of Mass Emergencies and Disasters*, 14(1), 5–22. Retrieved from <http://www.ijmed.org/articles/265/download/>
- Munasinghe, M. (2007). The importance of social capital: Comparing the impacts of the 2004 Asian Tsunami on Sri Lanka, and Hurricane Katrina 2005 on New Orleans. *Ecological Economics*, 64(1), 9–11. <http://doi.org/10.1016/j.ecolecon.2007.05.003>

- National Governor's Association Center for Policy Research Washington D.C. (1979). *Comprehensive Emergency Management: A Governor's Guide*.
- Orense, R. P., Kiyota, T., Yamada, S., Cubrinovski, M., Hosono, Y., Okamura, M., & Yasuda, S. (2011). Comparison of liquefaction Features observed during the 2010 and 2011 Canterbury earthquakes. *Seismological Research Letters*, 82(6), 905–918. <http://doi.org/10.1785/gssrl.82.6.905>
- Osborne, D., & Sibley, C. G. (2013). After the disaster: Using the Big-Five to predict changes in mental health among survivors of the 2011 Christchurch earthquake. *Disaster Prevention and Management*, 22(5), 456–466. <http://doi.org/10.1108/DPM-09-2013-0161>
- Osman, M., Hornblow, An., Macleod, S., & Coope, P. (2012). Christchurch earthquakes: how did former refugees cope? *The New Zealand Medical Journal*, 125(1357), 113–121.
- Parker, M., & Steenkamp, D. (2012, September). Reserve Bank of New Zealand Bulletin. *Reserve Bank of New Zealand Bulletin*, 75(3), 1–79.
- Pawson, E., & Banks, G. (1993). Rape and fear in a New Zealand city. *Area*, 25(1), 55–63.
- Pearson, A. L., Kingham, S., Mitchell, P., & Apparicio, P. (2013). Exploring hotspots of pneumococcal pneumonia and potential impacts of ejecta dust exposure following the Christchurch earthquakes. *Spatial and Spatio-Temporal Epidemiology*, 7, 1–9. <http://doi.org/10.1016/j.sste.2013.08.001>
- Quarantelli, E. L. (1994). Looting and antisocial behavior in disasters. *Encyclopedia of Criminology*, 1, 139–152. Retrieved from <http://dspace.udel.edu:8080/dspace/handle/19716/590>
- Renouf, C. A. (2012). Do the Psychological Effects of Ongoing Adversity in a Natural Context Accumulate or Lessen over Time? The Case of the Canterbury Earthquakes.
- Residents warned of hoax earthquake officials. (2011, February 25). *New Zealand Herald*. Retrieved from http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10708632
- Robertson, A. R., Stein, J. A., & Schaefer-Rohleder, L. (2010). Effects of Hurricane Katrina and other adverse life events on adolescent female offenders: A test of general strain theory. *The Journal of Research in Crime and Delinquency*, 47(4), 469–495. <http://doi.org/10.1177/0022427810375577>
- Rushton, G., Armstrong, M. P., Gittler, J., Greene, B. R., Pavlik, C. E., West, M. M., & Zimmerman, D. L. (2006). Geocoding in Cancer Research. *American Journal of Preventive Medicine*, 30(2), S16–S24. <http://doi.org/10.1016/j.amepre.2005.09.011>
- Sampson, R. J. (1987). Urban Black Violence: The Effect of Male Joblessness and Family Disruption. *American Journal of Sociology*, 93(2), 348. <http://doi.org/10.1086/228748>

- Sampson, R. J., & Groves, W. B. (1989). Structure and Crime: Testing Community Social-Disorganization Theory. *American Journal of Sociology*, 94(4), 774–802.
- Shaw, C., & McKay, H. (1942). *Juvenile Delinquency and Urban Areas*. Chicago: The University of Chicago Press.
- Siegel, J. M., Bourque, L. B., & Shoaf, K. I. (1999). Victimization after a Natural Disaster: Social Disorganization or Community Cohesion? *International Journal of Mass Emergencies and Disasters*, 17(November), 265–294.
- Siman, B. A. (1977). *Crime during disaster*. University of Pennsylvania.
- Skogan, W. G. (1974). The Validity of Official Crime Statistics: An Empirical Investigation. *Social Science Quarterly*, 55(1), 25–38.
- Smolej, M., & Kivivuori, J. (2006). The Relation Between Crime News and Fear of Violence. *Journal of Scandinavian Studies in Criminology and Crime Prevention*, 7(2), 211–227. <http://doi.org/10.1080/14043850601002429>
- Statistics New Zealand. (2011). *Estimating local populations after the 2010/11 Canterbury earthquakes*. Wellington.
- Stevenson, J. R., Kachali, H., Whitman, Z., Seville, E., Vargo, J., & Wilson, T. (2011). Preliminary observations of the impacts the 22 February Christchurch earthquake had on organisations and the economy: A report from the field (22 February - 22 March 2011). *Bulletin of the New Zealand Society for Earthquake Engineering*, 44(2), 65–76.
- Stewart, A. (2012, October 24). Fake contractors burgle homes. *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/7858173/Fake-contractors-burgle-homes>
- Stylianou, G. (2011, May 19). Drinking at home fans rise in domestic abuse. *The Press*. Retrieved from <http://www.stuff.co.nz/national/christchurch-earthquake/5023291/Drinking-at-home-fans-rise-in-domestic-abuse>
- Sullivan, S., & Wong, S. (2011). An enhanced primary health care role following psychological trauma: The Christchurch earthquakes. *Journal of Primary Health Care*, 3(3), 248–251.
- Teh, Y. K. (2008). The abuses and offences committed during the tsunami crisis. *Asian Journal of Criminology*, 3(2), 201–211. <http://doi.org/10.1007/s11417-008-9050-7>
- Thornley, A. M. (2004). *Crime in Space and Time: A Spatial and Temporal Analysis of Burglary in Christchurch*. University of Canterbury. Retrieved from <http://hdl.handle.net/10092/1362> <http://ir.canterbury.ac.nz/handle/10092/1362>
- Thornley, L., Ball, J., Signal, L., Lawson-Te Aho, K., & Rawson, E. (2013). Building community resilience: learning from the Canterbury Earthquakes. In *Proceedings of the 2013 Public*

Health Association Conference.

- Varano, S. P., Schafer, J. a., Cancino, J. M., Decker, S. H., & Greene, J. R. (2010). A tale of three cities: Crime and displacement after Hurricane Katrina. *Journal of Criminal Justice*, 38(1), 42–50. <http://doi.org/10.1016/j.jcrimjus.2009.11.006>
- Walker, W. C., Sim, S., & Keys-Mathews, L. (2012). The Impact of Hurricane on Spatial-Temporal Patterns of Crime in Mobile, Alabama, (1), 1–6.
- Walker, W. C., Sim, S., & Keys-Mathews, L. (2014). Use of Geographically Weighted Regression on Ecology of Crime, Response to Hurricane in Miami, Florida. In A. Elmes, Gregory, G. Roedl, & J. Conley (Eds.), *Forensic GIS: The Role of Geospatial Technologies for Investigating Crime and Providing Evidence* (pp. 245–262). Springer Netherlands. <http://doi.org/10.1007/978-94-017-8757-4>
- Wallace, C. (1995). Earthquakes in the New Zealand Region. *New Zealand Journal of Geography*, (April), 3–17.
- Watanabe, K., & Tamura, M. (1995). Victim's Behavior in the Great Hanshin Earthquake and Disaster Countermeasures of the Police. *Reports of the National Research Institute of Police Science*1, 36(2), 29–29.
- Wilson, J., Phillips, B., & Neal, D. (1998). Domestic violence after disaster. *The Gendered Terrain of Disaster*, 115–122. Retrieved from http://www.academia.edu/download/30447142/9__Wilson__Phillips__Neal._pdf.pdf \nhttp://s3.amazonaws.com/academia.edu.documents/30447142/9__Wilson__Phillips__Neal._pdf.pdf?AWSAccessKeyId=AKIAIR6FSIMDFXPEERSA&Expires=1376471198&Signature=eAoi+1xRA6laTJmPLuSCj
- Young, R. (2014, July 24). Suspected arson in central Christchurch. *The Press*. Retrieved from <http://www.stuff.co.nz/the-press/news/10304568/Suspected-arson-in-central-Christchurch>
- Zahran, S., Shelley, T. O., Peek, L., & Brody, S. D. (2009). Natural Disasters and Social Order: Modeling Crime Outcomes in Florida. *International Journal of Mass Emergencies and Disasters*, 27(1), 26–52.
- Zhou, D. (1997). *Disaster, Disorganization, and Crime*. University of Albany, State University of New York.